F I N A L R E P O R T

ESTABLISHING AND VALUING THE EFFECTS OF IMPROVED VISIBILITY IN EASTERN UNITED STATES

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Section 1

INTRODUCTION

1.1 SUMMARY OF PROJECT OBJECTIVES

While visibility is receiving increasing attention, it is still relatively neglected as an attribute of the environment whose worth is important. Visibility is a pervasive and inescapable phenomenon which is subject to both general and periodic deterioration. The effects are significant to the individuals affected, and extremely large numbers of people are affected. The relative neglect of visibility as a subject of investigation appears to be due not to its lack of importance, but rather to the fact that it is more difficult to value than many other environmental attributes. Visibility is not explicitly bought and sold, and the consequences of poor visibility are not as overt as illness and death. Yet visibility affects the quality of life and is potentially important to well-being.

Valuing visibility raises methodological questions to which recent contributions have been made. The present effort utilizes and develops these contributions, enhancing their validity and accuracy. Previous work on visibility has concentrated on sparsely populated areas of the West. The present research, concerned with visibility in the Eastern United States, deals with larger numbers of people under a wider variety of circumstances. People in urban and rural areas are affected in the course of daily living, and a variety of special activities centering on recreation and related activities are particularly sensitive to visibility conditions.

Three major objectives have been accomplished by the research contained in this Report. The first and most important result is the establishment of a visibility value function. This function is the Project's basic contribution to the analysis of visibility policy effects. Research was directed not at measuring

the value of current visibility or any other specific value, but rather at estimating the value of policy-induced changes in visibility. The generality of the visibility value function permits estimation and comparison of benefits from any set of policy alternatives.

The benefits of a visibility policy depend upon the extent of improvement, on initial visibility conditions and their geographic distribution, and upon social and economic characterisrics of people in various regions. Benefits are a function of these variables in the visibility value function. Changes in socioeconomic characteristics of the population will occur over time as well as policy-induced visibility changes. The visibility value function accounts for the separate and joint effects on benefits of changes in these variables over time.

The second major objective was to identify particular activities likely to be influenced by visibility and to measure the value of visibility to households in producing these activities. Recreational swimming and enjoyment of residential views are among the wide range of activities investigated. Visibility value functions for individual activities were derived. The individual activity functions compliment the aggregate function in several important ways. Theoretically, they are based upon information derived from transactions in ordinary markets or from activity in implied markets. An important result is that these studies corroborate the findings from the aggregate function, which is based upon hypothetical behavior in contingent markets. First, the activity functions consistently establish positive values for improved visibility in individual markets. One example is that property values are observed to increase with improved visibility. Secondly, the magnitudes of benefits in individual

markets are plausible in relation to aggregate benefits.

The third major contribution of Project research was to establish a rigorous and operational method of aggregating visibility policy benefits over the entire Eastern U.S. From the beginning it was recognized that the visibility value function, based upon contingent valuation, would be the basis for measuring aggregate policy benefits. This is because it was not feasible to develop individual value functions for all markets in which visibility is important.

The basic problem was to use a limited amount of information obtained from contingent markets in six cities to measure visibility valuation in the entire eastern U.S. Approximately 800 expressions of willingness to pay were obtained for five visibility programs. Each program covered a specific geographic area and offered a specific change in visual range.

An early empirical approach was to estimate a separate willingness to pay function for each program in each city. Several aggregation problems resulted. First, there was only one eastern U.S. policy program to use (along with the endowment point) to fit the eastern bid curve. This was inadequate. Secondly, there was no satisfactory way to estimate willingness to pay for improvements at different distances from the bidder. One would have to resort to an expedient like "average improvement over all eastern states" as an argument of a city's eastern U.S. bid function. Thirdly, estimation of policy benefits required adding values derived from local bid functions and values derived from eastern U.S. bid functions. This was rather arbitrary in that local visibility improvements and distant visibility improvements were treated as separate goods, rather than as a single good which yields different service flows at different distances.

These difficulties were overcome by pooling all observations and estimating a single function directly applicable to all bids, both local and region-wide.

The resulting visibility value function permits direct aggregation of all policy benefits based upon parameter values derived from a quite limited but carefully chosen set of contingent market observations.

The spatial index is the feature of the visibility value function that produces direct aggregation of policy benefits. The index expresses willingness to pay for visibility in any location as directly related to the number of square miles of improvements and inversly related to distance. Thus, the benefits of a policy in a state in a particular year are a function of policy-induced improvements in all states that year. Estimates of policy benefits take account not only of the size but also of the complicated and changing spatial distribution of visibility improvement over time.

This report is a summary of a 32-month effort aimed at arriving at estimates of the value of improved visibility for the Eastern United States. The project was carried out under a Cooperative Agreement with the Environmental Protection Agency, with active day to day participation by the staff of the Resource Analysis Group of the Committee on Public Policy Studies of the University of Chicago and the staff of the EPA, including Dr. Alan Carlin and others.
Austin Kelly of the University of Chicago and James Ciecka of DePaul University served as consultants to the project.

The project was completed in two phases. The basic phase ran from Month 1 through Month 17, during which time detailed methodology was developed and visibility situations examined for the Chicago area. The supplementary phase of the project, running from Month 8 through Month 32, was devoted to examining six additional metropolitan areas and six non-urban cases.

1.2 ECONOMIC EFFECTS ON VISIBILITY

1.2.1 Economic Effects: Introduction

The history of visual air quality in the eastern United States is essentially a history of economic development of the region. The relationship between economic development and visibility has changed over the years in response to changing technology, energy prices and other factors. A requirement of effective visibility policy is to alter the direction of these occurrences optimally.

Measurement of policy effects requires a knowledge of historical trends. Policy evaluation requires that regulatory rules be modelled in proper relationship to other factors, so that their partial effect on visibility may be isolated.

1.2.2 Visibility in the Eastern United States Since World War II

Examination of the path of visibility in the twentieth century provides many insights into the short and long term factors which influence pollution and visibility in the eastern United States.

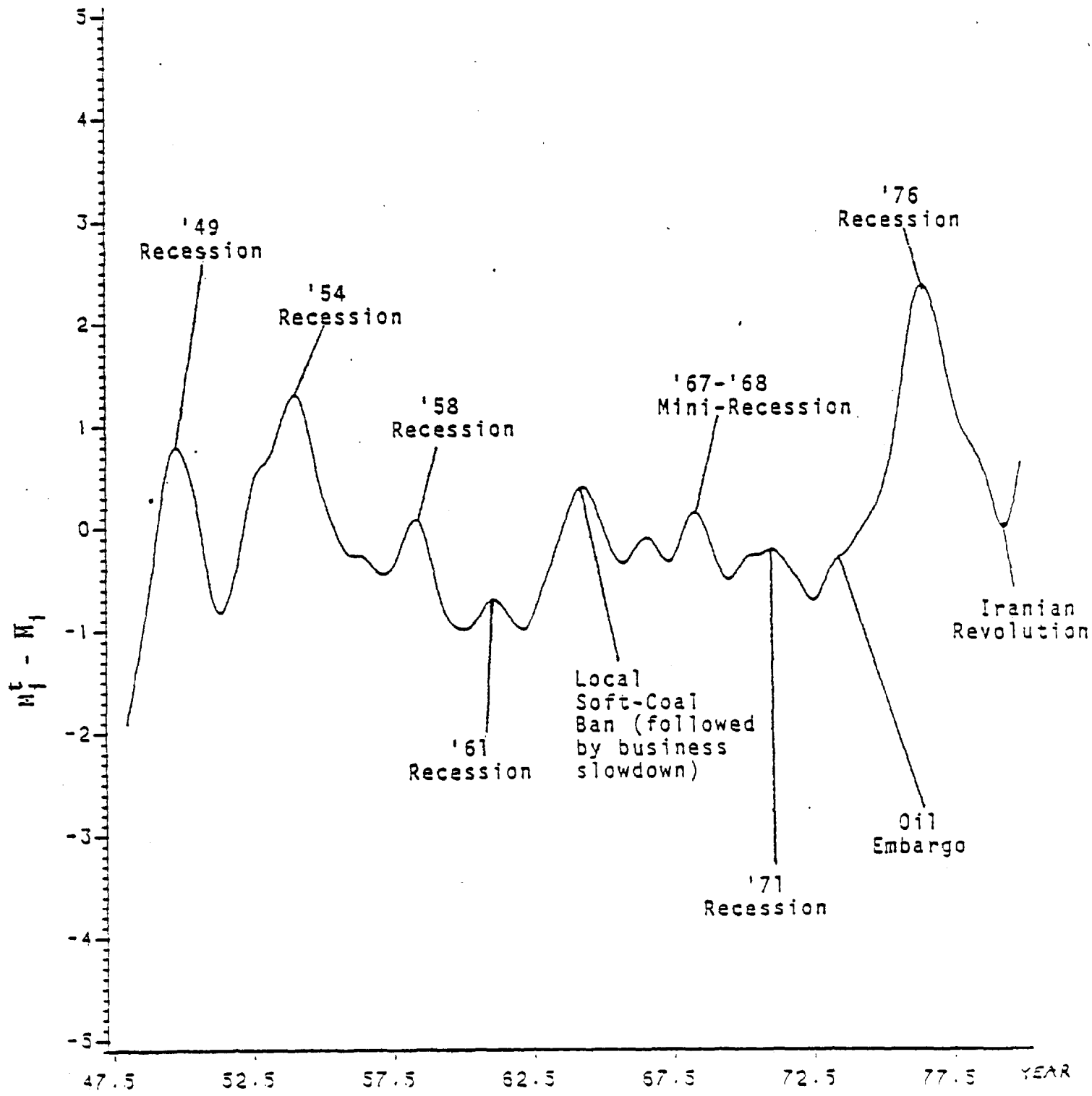
Visibility trend data were initially used in the scenario-setting of the contingent valuation (CV) portion of this study. Examination of the data

immediately raised a difficult question: Just what is typical visibility in these urban areas: Median visibility over the last four years was used, buy a satisfactory answer to the question still requires some knowledge of the history of visibility and its determinants in these cities.

Fig. 1-1 shows a seasonally-adjusted time-series of visibility in Chicago. The vertical scale represents the difference between the month's median visibility and the average median for the particular month over the entire series. While this method is flawed, in that seasonal shifts have occurred in the pattern of visibility, it is nevertheless useful in showing the distinguishing features of the trend line, which has been smoothed somewhat using a modified spline routine. Fig. 1-2 through 1-4 repeat the exercise for Atlanta, Boston, and Cincinnati. Fig. 1-5 presents all four cities simultaneously, to aid in regional comparisons. The major features are presented below. In Fig. 1-5 the vertical, broken lines occur at the midpoints of business troughs, while the first solid vertical line occurs at the time of the OPEC oil price hikes of 1973-1974. The second solid vertical line occurs at the Iranian Revolution, which was accompanied by another round of oil cutbacks and price hikes. It is important to note at this point that substitute fuels respond to oil price hikes, as demand for them increases. Fig. 1-6a shows a deflated (1972 dollars) schedule of several fuel prices, in energy equivalents, as well as a quantity-weighted composite of all mineral fuel prices in the United States since 1950. It is clear that economic activity and relative factor prices influence pollution and visibility. Any projections of future trends should carefully consider these effects. As an example, Fig. 1-7 shows the trend of visibility at O'Hare Airport in Chicago. This series is interesting in that more

FIGURE 1-1

Median Visibility at Chicago-Midway:
Difference From Sample Mean



Source: National Climate Center
Bureau of Labor Statistics

Note: Recessions are drawn at local troughs

FIGURE 1-2

Difference From Mean Monthly Vis.
City = Atlanta

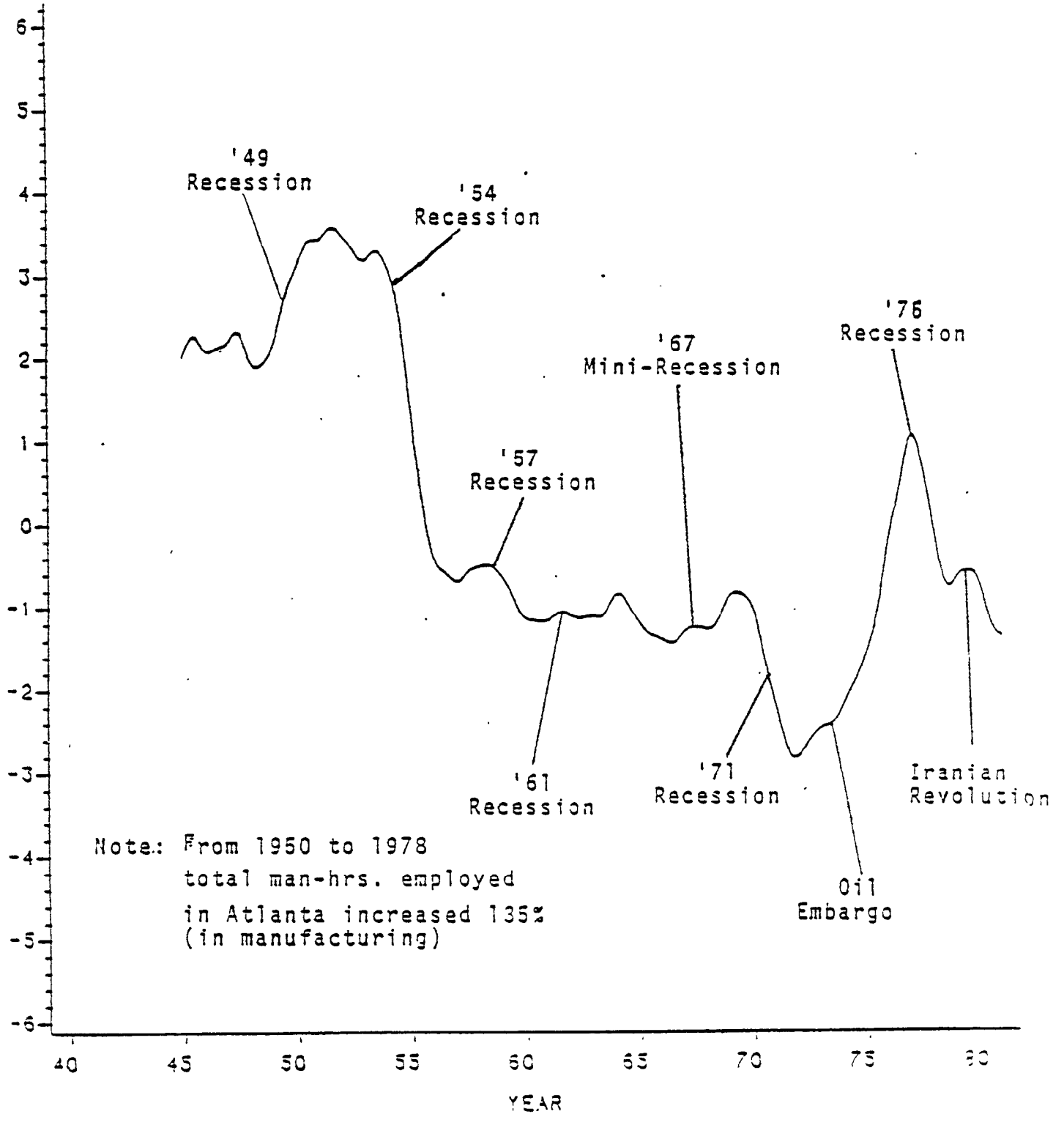


FIGURE 1-3

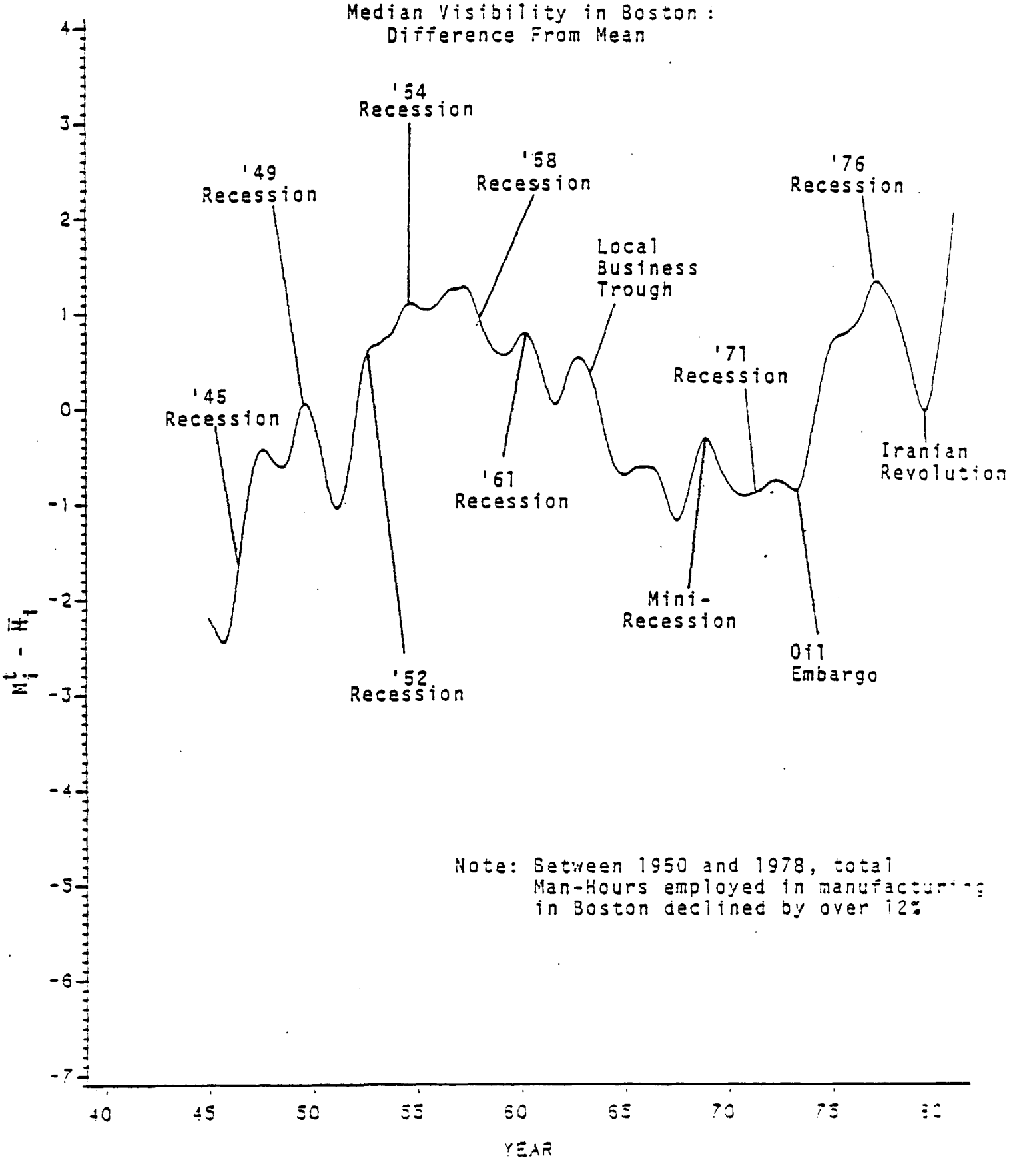

Median Visibility in Boston:
Difference From Mean
'54 Recession
'49 Recession
'58 Recession
'76 Recession
Local Business Trough
'71 Recession
'45 Recession
'61 Recession
Iranian Revolution
Mini-Recession
Oil Embargo
'52 Recession
Note: Between 1950 and 1978, total Man-Hours employed in manufacturing in Boston declined by over 12%
$M_i^t - \bar{M}_i$
YEAR

FIGURE 1-4

Monthly Median Visibility in Cincinnati:
Difference from Month's Sample Mean

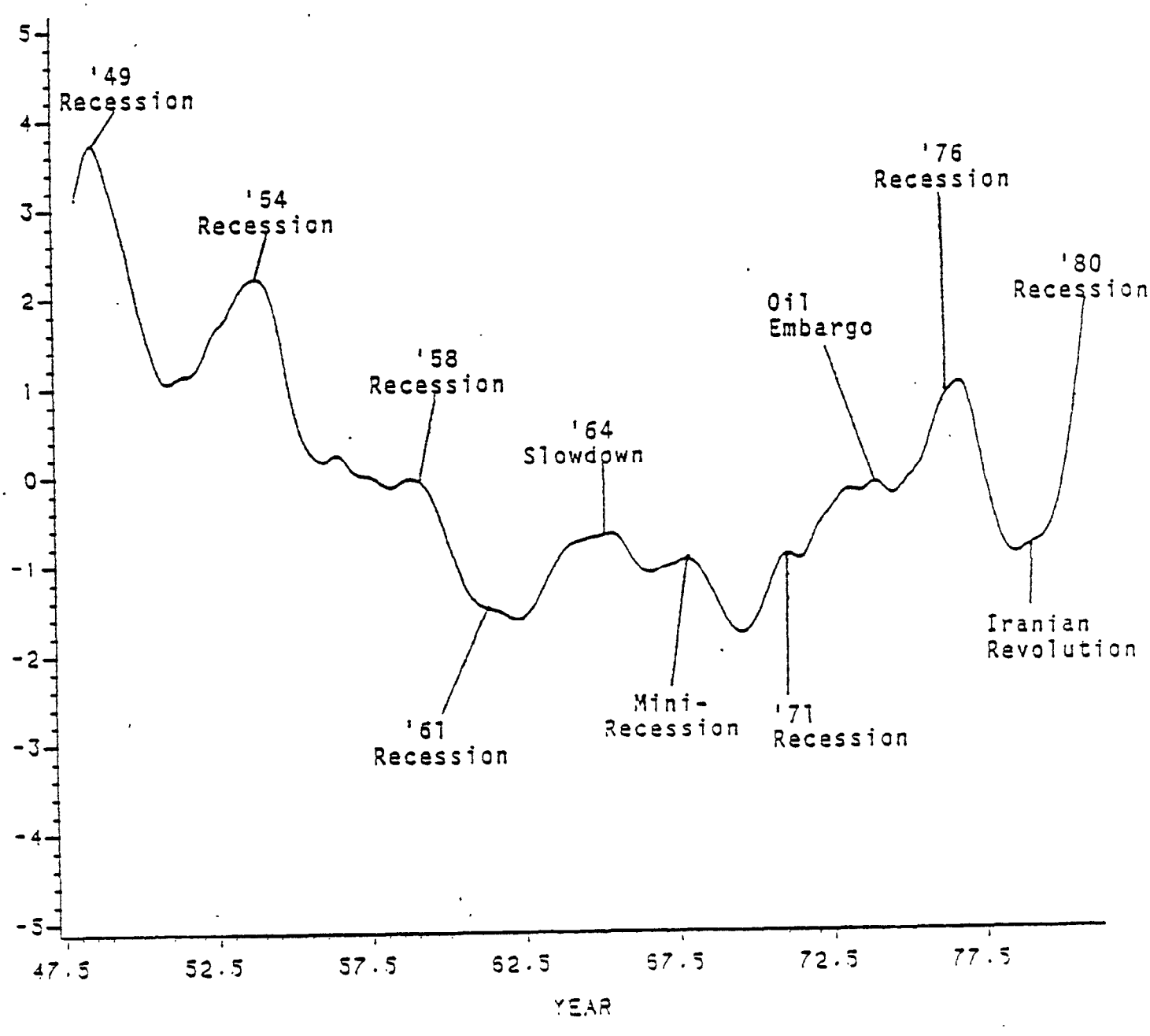
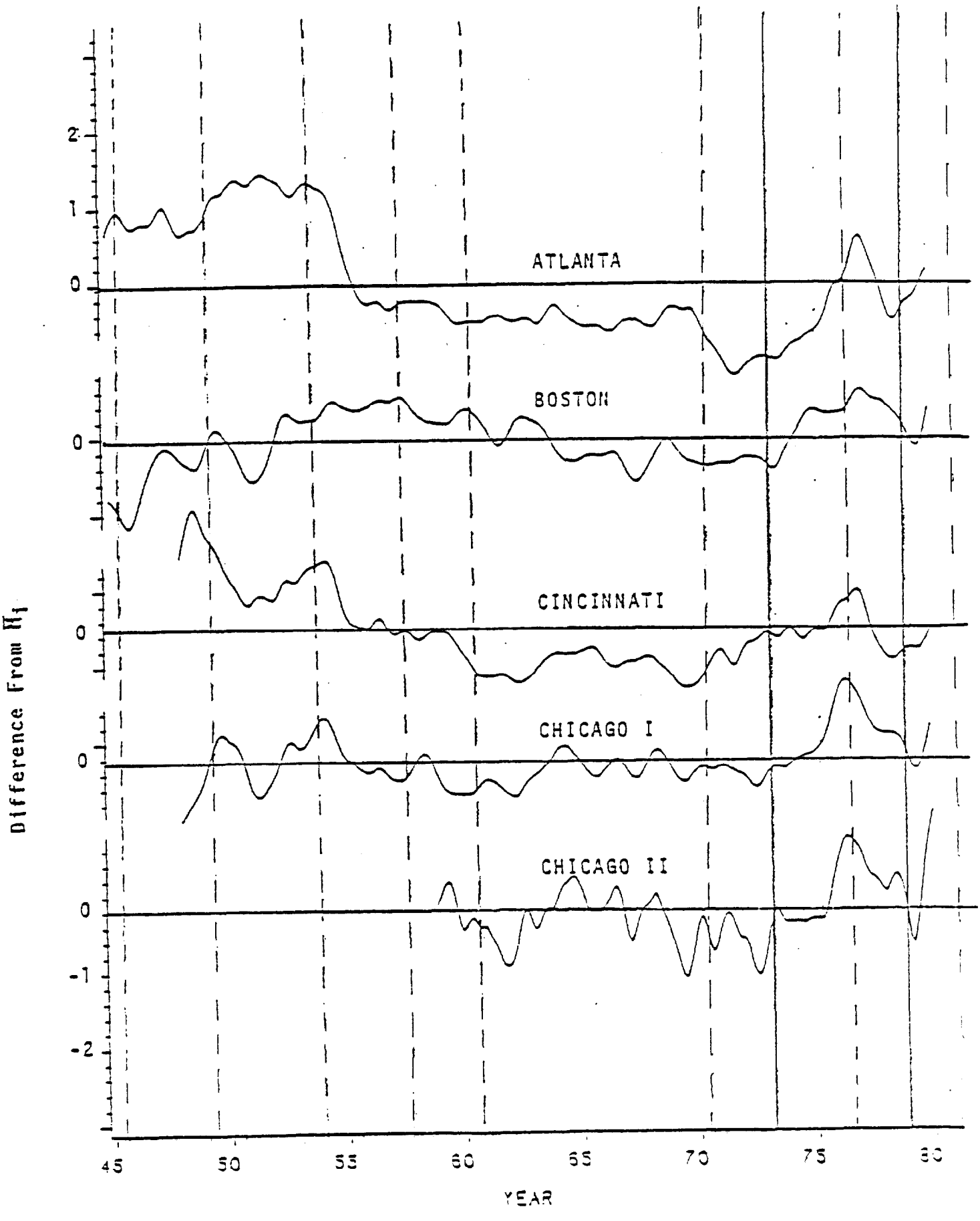
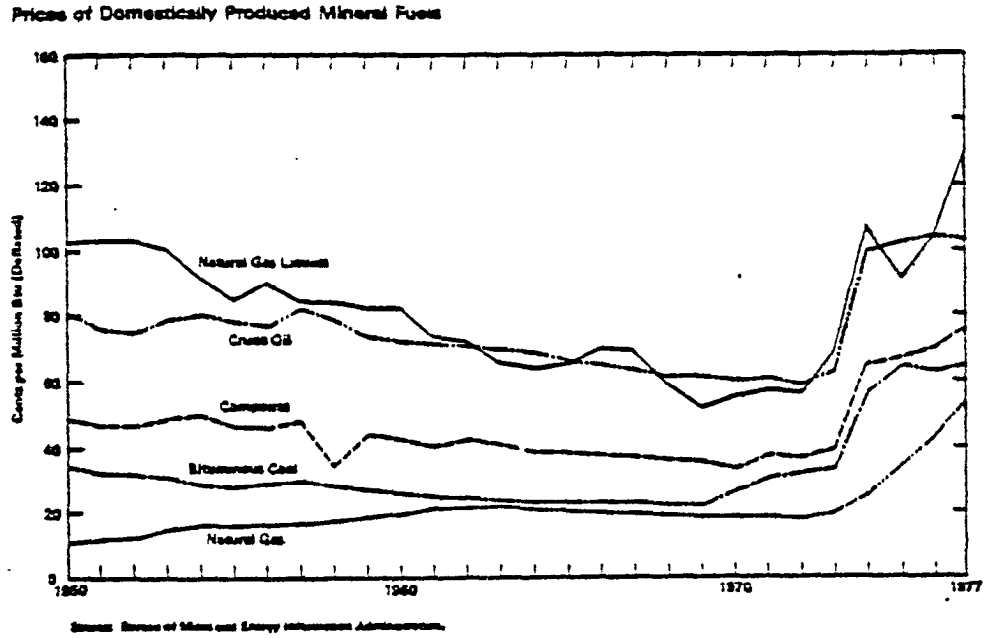


FIGURE 1-5



LEGEND: Broken vertical lines are U.S. Recessions. First solid line occurs at oil Embarco. Second occurs at Iranian Revolution.

FIGURE 1-6a



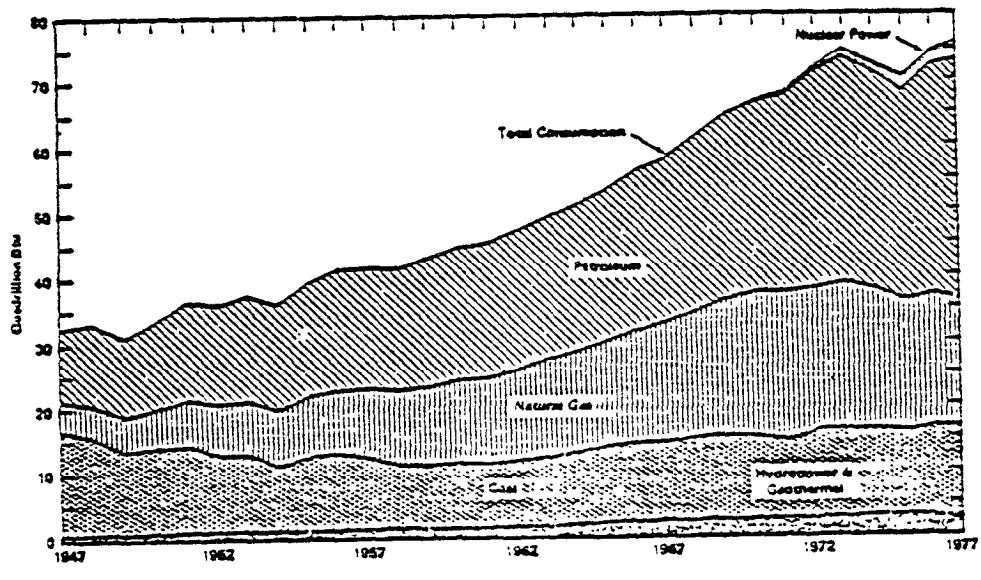
The deflated (real) composite price of U.S. fossil fuels declined at an annual rate of 0.9 percent from 1950 through 1973. Since 1973, this price has increased at a rate of 17.9 percent per year.

The average real domestic crude oil price decreased 1.1 percent per year between 1950 and 1973, then jumped 58.3 percent in 1974. During the 1975–1977 period, crude oil prices grew at an annual rate of 1.2 percent.

Real natural gas prices increased from 1950 through 1973 at a rate of 2.5 percent per annum. In 1974 this price rose 15.4 percent, and then from 1975 through 1977 increased at an annual rate of 7.4 percent.

Real bituminous coal prices fell an average of 0.1 percent per year between 1950 and 1973, then increased 66.7 percent in 1974. From 1975 through 1977, the annual growth rate for bituminous coal prices was 4.9 percent.

FIGURE 1-6b



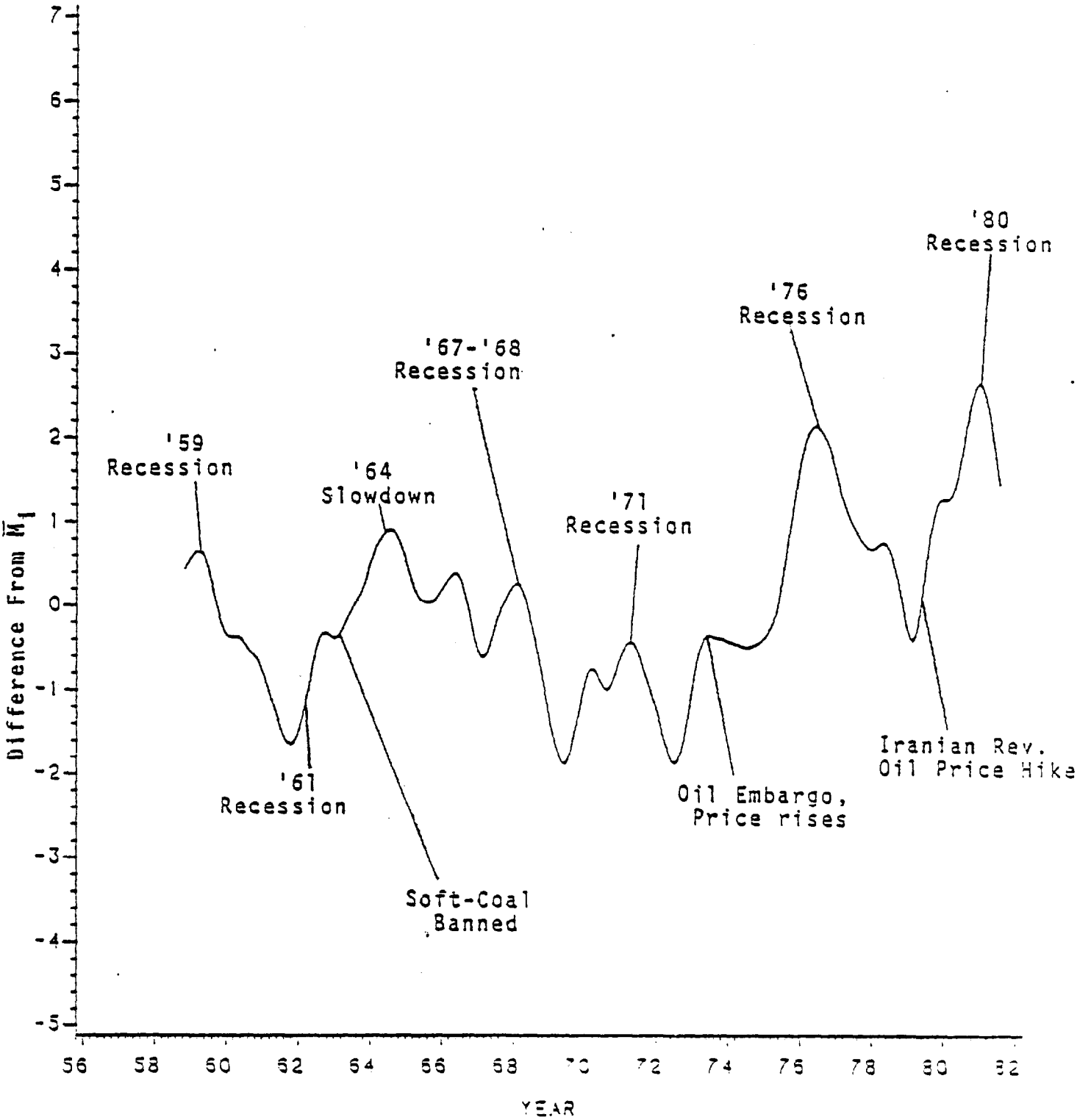
Between 1947 and 1973, consumption of energy in the United States increased at an annual rate of 3.2 percent. During this period, petroleum and natural gas consumption grew at annual rates of 4.5 percent and 6.4 percent, respectively.

During 1974 and 1975, total U.S. energy consumption fell 2.7 percent per year. But then increased in 1976 and 1977 by 5.3 percent and 2.0 percent, respectively. Petroleum consumption in 1974–1975 decreased 2.9 percent annually, and then increased an average of 4.2 percent per year in 1976 and 1977. Natural gas consumption declined 3.1 percent annually from 1974 through 1977.

Coal consumption declined 3.9 percent annually from 1947 to 1959, then increased 3.0 percent per year through 1977. In 1947, coal, natural gas, and petroleum held 44.8 percent, 11.9 percent, and 34.9 percent, respectively, of total U.S. energy consumption. In 1977 these shares were 18.4, 25.7, and 46.7 percent, respectively.

FIGURE 1-7

Monthly Median Visibility at Chicago-O'Hare:
Difference from Sample Mean, by Month, 1958-1981



Sources: National Climatic Center
Bureau of Labor Statistics

Note: Recessions are drawn at the local troughs

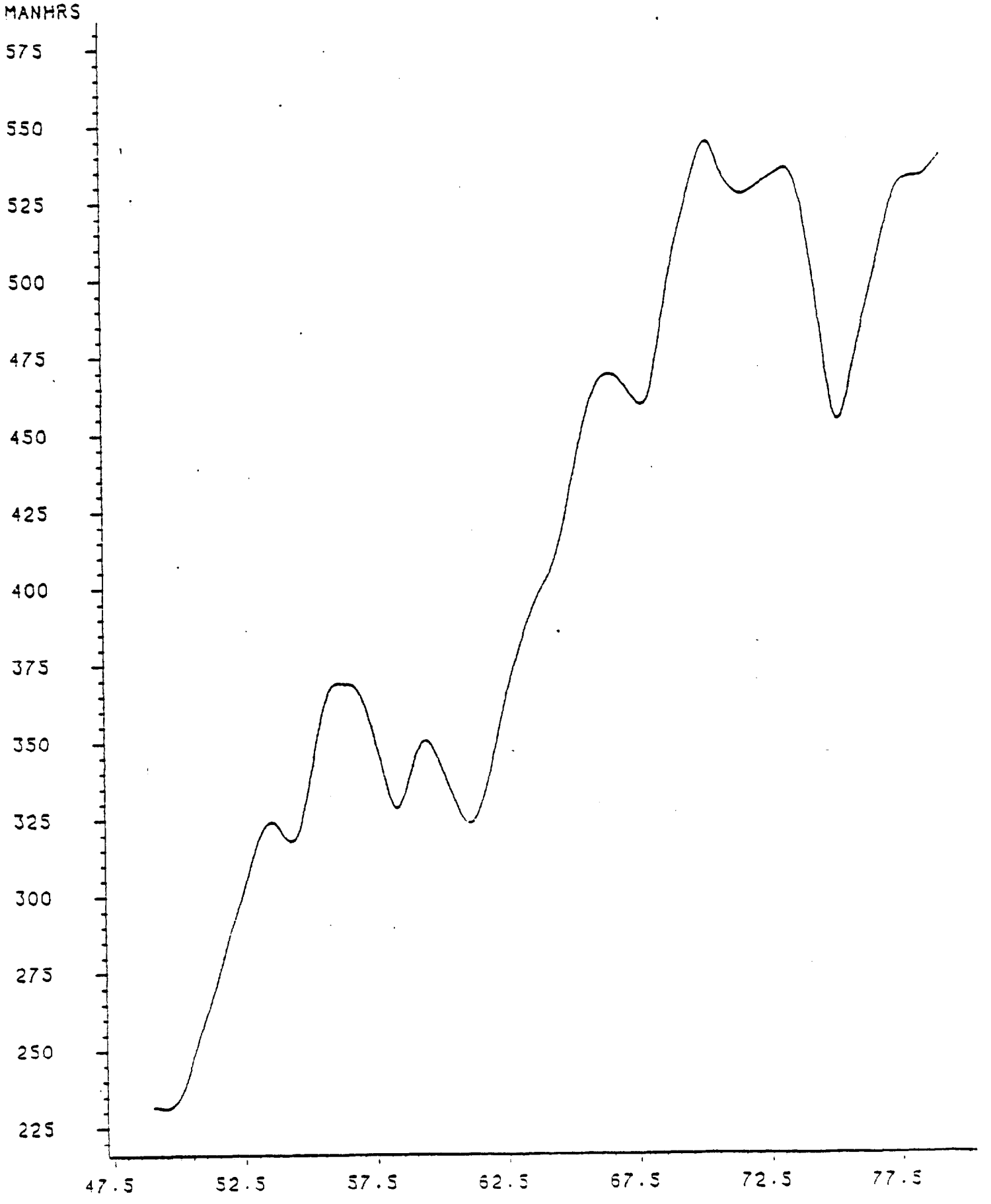
recent levels are available, and have been added to the plot. The recession of 1975-1976 increased visibility. Following this is the recovery into 1978, when visibility fell once again. In 1979, the oil price hikes again increased visibility, and the 1980 recession followed soon thereafter. The quick recovery from this recession is seen at the end (September 1981) of the series, and we are confident that additional data would again reflect the business downturn beginning in the final quarter of 1981.

This kind of historical analysis is primarily intended to explain the short-run peaks and valleys of the observed series, but the method is equally valid for longer time periods. As an illustration, the plot of median visibility in Atlanta should be compared with the plot of employment in manufacturing industries for the same city (Fig. 1-8). Atlanta was chosen because of its dramatic pattern of growth. During episodes of rapid growth in the 1950's, and again in the early 1970's, Atlanta's visibility declined appreciably. No doubt this was also influenced by regional growth in general as well as local growth. In almost all cases, a decline in employment was matched closely with an increase in visibility. More precise econometric estimates of the effects of legislation, fuel prices, and business cycles will aid in the prediction of policy benefits, especially as more refined estimates of future fuel prices are developed. The effects of legislation on visibility, and pollution in general, are difficult to measure, as the 1970's also saw so much economic turmoil. Persons should be cautioned against the indiscriminant use of two-year comparisons of pollutant levels, as a look at these graphs clearly shows that the choice of end points can be made to produce almost any trendline of pollution.

The best that can be said of typical visibility is that it is the level of visibility which exists with a typical level and rate of growth of economic

FIGURE 1-8

ATLANTA MAN-HOURS (THOUSANDS)
Total Manufacturing



activity, typical fuel prices, wages, and prices of other production inputs, and typical weather conditions. It is clear that it is neither valid nor informative to base policy oriented pollution projections on trend data assembled from spot readings taken several years apart. It is hoped that more reliable projections will be made through careful econometric estimation procedures.

1.3 DEFINITION AND MEASUREMENT OF VISIBILITY

Visibility is rooted in human perception. As atmospheric conditions change, the human perception of distance, clarity, color, texture and contrast change. An adequate notion of visibility, as related to atmospheric quality, involves (1) relationships between atmospheric conditions and those atmospheric quality attributes which are objectively measurable with scientific instruments, and (2) relationships between measurable quality attributes and human perceptions of visual quality.

Visibility traditionally has been defined as the relative distance at which an object can be seen under the prevailing conditions; i.e., as the visual range. Husar et.al. (1979) define visibility as the maximum distance at which an observer can discern the outline of a black object. According to Trijonis and Yuan (1978) the procedure commonly used to determine visibility is to observe markers against the horizon sky, e.g., buildings or mountains during the daytime and unfocused, moderately intense light sources at night. Markers are chosen whose distance from the observation point is known. Prevailing visibility is the greatest visibility that is met or exceeded around at least 50 percent of the horizon circle. The procedure has two limitations. The measurement of visibility is affected by the visual acuity of the observer and the quality of objects observed. The latter leads to a systematic underestimation of daytime visibility because the objects are rarely black as required by the definition. There is an even greater problem with measurement of nighttime visibility because of the variation in intensity of the light sources. This lack of standardization makes accurate comparisons of visibility among different sites difficult, especially for nighttime visibility. There seems to be reasonable confidence in comparison of daytime visibility among sites probably because less variation in the charac-

teristics of target objects is suspected. Visibility is the good that individuals value, measured in this Report in miles.

Natural scientists who are concerned with the relationship between visibility and pollutants have found it convenient to study the "bad"--haziness or lack of visibility. Haziness is increased by the presence of light scattering and absorbing aerosals and gases and is proportional to their concentration in the air. Trijonis and Yuan measure haziness by the extinction coefficient (B), which is inversely proportional to visibility (V) in the following way:

$$(1\text{-}1)\quad B = 24.3/V\ ,$$

where 24.3 is the Koschmieder constant, V is measured in miles and B has the units $(10^4 \text{ meters})^{-1}$. The relationship means that in a uniform atmosphere with extinction coefficient equal to $x(10^4 \text{ meters})^{-1}$, a black object against the horizon sky will be reduced to the threshold level of contrast for the human eye at a distance of 24.3/x miles. It is the extinction coefficient that is used to determine the causes of haziness. Both the extinction coefficient and visibility are used to describe air quality patterns and trends.

In addition to visual range, important components of human perception of atmospheric visual quality include color and texture. These concepts can be measured objectively as contrast, color and lightness, using scientific instruments. Formulae have been developed to combine these concepts into a single parameter called color contrast (Malm, Leiker, and Molenar). Research in which personal interview subjects rated carefully calibrated color slides and actual scenes for visual quality has established that the relationship between color contrast and perceived visual quality is linear and statistically significant. Other factors such as scenic beauty serve as shifters, leaving the essential linear relationship between color contrast and perceived visual quality intact.

Several prominant patterns and trends are reported by Trijonis and Yuan. First, visibility is rather low in the Northeast, ranging from 8 to 14 miles typically. In the Southwest, visibility ranges from 30 to 80 miles. Second, visibility is fairly uniform throughout the Northeast in that visibility is only 2 or 3 miles less in urban than nonurban areas. Third, there is a seasonal pattern in that visibility is now typically 2 to 3 miles lower in the summer quarter than the rest of the year, especially for non-metropolitan (urban/suburban and nonurban) locations. Fourth, over the period 1953 to 1972, visibility declined in the Northeast, -2 percent for metropolitan areas. It appears most of the decline occurred early in the period.

Trijonis and Yuan explain the deterioration in visibility by an increase in sulfates in the atmosphere. Sulfates tend to occur in the particle size range of 0.1 to 1 micron, which is the size range that is optically most important. Despite the fact that sulfates comprise only 15 percent of the aerosal mass, they account for approximately 50 percent of the reduction in visibility in the Northeast. Through multivariate analysis of the extinction coefficient Trijonis and Yuan find contributions to total extinction as follows:

Component	Contribution
Sulfates	49%
TSP*	16%
Blue-sky scatter (background)	5%
Nitrates	2%
Unaccounted for	28%

*TSP is total suspended particulate other than sulfates and nitrates.

The conclusion that sulfates are the primary cause of visibility reduction is robust with respect to six different data sets and linear and nonlinear specifications. Physical modeling which relates sulfate reductions in one area of the Northeast to visibility in the other areas of the Northeast--a distributional concern--has been supplied by D.M. Rote of ANL, and is used in the policy simulation chapter of this report.

1.4. OUTLINE OF THE REPORT

Section 2 is "Expressed Willingness to Pay for Visibility." This is the first major empirical part of the Report. Analysis is based upon data drawn directly from contingent markets in six eastern cities.

The most important literature on contingent valuation is reviewed in 2.1. Important extensions of this literature are made in design, reported here, of a contingent valuation research project carried out in Chicago. The project made a fundamental contribution to the main results of this Report.

In 2.2 it is argued that geographically dispersed visibility improvements are substitutes. Empirical support provided for the theoretical argument. This work was fundamental to the development of the contingent valuation instrument and the visibility value function, which are the key elements of Section 2 research.

Alternative econometric approaches to estimating the parameters of the visibility value function are discussed in 2.3. Tobit estimation, discussed in 2.3.2, is applied to a contingent valuation study at Indiana Dunes State Park. Tobit and probit specifications are compared with ordinary least squares in 2.3.3, in an application to National Park Service data.

The visibility value function is presented and analyzed in 2.4. Drawing upon the theory of household production, it is an empirical statement which summarizes the information gathered from the contingent valuation work. Aggregate policy benefits by state are derived by substituting mean state values for each of the variables in the function.

Section 3 is the second major empirical part of the Report: "Secondary Data Analysis of Visibility Valuation." "Secondary Data" includes information such as prices and quantities determined in ordinary markets. The term also denotes infor-

mation about behavior in implicit markets, such as increased probability of accident while driving at a slower speed under reduced visibility conditions. This can be interpreted as in increased price of safety.

A brief description of each topic, and corresponding empirical results, are given in 3.1. Section 3.2.1 analyzes visibility effects on outdoor swimming. A theoretical model of visibility demand is developed and tested by means of several regression specifications. In 3.2.2 and 3.2.3 the effects of changing visibility on television viewing and baseball attendance are analyzed. The theoretical foundation of these studies is the idea of visibility as a productive input which households use to produce services that yield satisfaction. Relevant theory is developed in the Conceptual Appendix.

Section 3.3.1 reports the development of statistical procedures for analyzing Hancock Tower visitation, and estimates of consumer surplus from improved visibility The Hancock analysis is continued in 3.3.2. Results of contingent valuation and analysis of secondary data from the Tower are found to be in close agreement with contingent valuation results of the kind reported in Section 2. This comparison greatly strenghtens confidence that can be placed on both types of analysis employed in this Report. In this study of the value of residential view quality and atmospheric visibility, property value and contingent valuation estimates of visibility were found to be compatible. Benefits estimates of improved view quality and visibility are reported.

A model of consumer behavior under visibility constraints on air travel is developed in 3.5.1, and a framework is provided for measuring the net costs of lowered visibility on air travel in 3.5.2. The relationship between visibility and highway accidents on metropolitan Chicago is examined in 3.5.3. Underlying the quantitative estimates is a behavioral theory of choice in which drivers are assumed to balance the risks of injury or death against travel objectives. Consumer surplus estimates of visibility benefits are reported.

Section 4, "Use of Results to Estimate Benefits for the Eastern United States," shows how the visibility value function can be used to derive dollar estimates of policy benefits. Four alternative illustrative policies are analyzed. Each policy produces a set of state-by-state visibility improvements to the year 2000, as determined by the Argonne long range transport model. More stringent policies produce greater visibility improvements, which are distributed unequally among the states. The benefits received by a state are seen to depend not only upon local improvements but also importantly upon improvements in all other states as well. Benefit estimates for each eastern state in 1990 under the four hypothetical scenarios are presented.

Section 2

EXPRESSED WILLINGNESS TO PAY FOR VISIBILITY

2.1 OVERVIEW OF SECTION 2

The major objective of Section 2 is to formalize an aggregate visibility value function. This function is the central contribution of Project research to the measurement of region-wide visibility policy benefits.

In Section 2.2, a general theoretical framework of visibility valuation is developed. It pertains both to the contingent valuation work of Section 2 and the analysis of secondary data in Section 3. The theory and practice of contingent valuation are then reviewed. Project contributions to this literature are explained in detail. The empirical data used in the Project were gathered in conformity to the framework established in the section.

Section 2.3 is an investigation of econometric approaches to data analysis. Section 2.4 presents the visibility value function and its underlying rationale.

2.2 ALTERNATIVE CONTINGENT VALUATION APPROACHES

2.2.1 Overview of Section 2.2

The basic problem addressed in this Section is the gathering of reliable data on maximum willingness to pay for visibility improvements by the contingent valuation (CV) approach. Sections 2.2.2 and 2.2.3 give a critique of the current state of CV literature, stressing issues that need special care in visibility valuation. This is followed by a general theoretical model of household production of visibility services, 2.2.4, in which visual air quality and purchased goods are productive inputs. The household production model and regional economic theory--spatial economics--underlie the content of the CV instrument. Section 2.2, therefore, addresses the two basic issues: what information is needed and how most effectively to obtain it.

2.2.2 The Process by Which Atmospheric Visibility Acquires Economic Value

2.2.2.1 The Conceptual Model

Atmospheric visibility is desired by households not so much as a commodity for direct consumption but rather as an input into the production of things (variously called "commodities" or "activities") which yield satisfaction. Thus, the "new" demand theory of Lancaster and the household production approach of Becker are both relevant. Stoll, building on the work of Lancaster and Becker, developed a conceptual model of the process by which environmental resources yield satisfaction, and applied it to the analysis of wildlife-related outdoor recreation. The following is a modification of Stoll's approach, specifically designed to recognize the nonrival character of the good, atmospheric visibility.

Assume that the household seeks to maximize the satisfaction it derives from the characteristics provided by the activities it produces. Activities are produced by combining time with exclusive, priced goods, and nonexclusive and/or nonrival goods. Thus both time and goods serve as inputs into activity production. The process of producing activities is constrained by the household's activity production function (a mathematical depiction of its consumption or household production technology) and by constraints on available time and income. Assuming, as does Becker, that time may be traded for wages, these two constraints may be combined into a "full income constraint."

Symbolically, the process may be depicted as one in which the household maximizes

$$(2\text{-}1) \qquad U(c_1 \ldots, c_m, \ldots, c_M)$$

Subject to

$$(2\text{-}2) \qquad \sum_{j=1}^{B} \left(\sum_{n=1}^{N} p_n x_{jn} + T_j \bar{r}_{B+1} \right) \leq S$$

$$(2\text{-}3) \qquad w_{jk} = W_k \qquad k = 1,2,\ldots,L$$

$$(2\text{-}4) \qquad z_j = z_j(x_{jn}, T_j \mid w_{jk}, E) \qquad \begin{matrix} j = 1,2,B,\ldots,J \\ n = 1,2,\ldots,N \end{matrix}$$

$$(2\text{-}5) \qquad c_m = c_m(z_j, w_{jk}) \qquad m = 1,2,\ldots,M$$

$$(2\text{-}6) \qquad z_j \geq 0$$

where c_m are characteristics; z_j is an activity; $z_1, \ldots, z_B$ are nonwork activities, and $z_{B+L}, \ldots, z_j$ are work activities; x_n is a purchased input whose unit price is p_n; w_k is a nonrival good; $\bar{r}_{B+L}$ is the unit wage rate for the highest-marginal-wage work activity available; S is full income; W_k is the total initial endowment of nonrival good; and E is a vector of determinants of the household's activity production technology at a given point in time.

Constraint (2-2) is the full income constraint; (2-3) is a constraint on availability of nonrival goods; (2-4) is a household activity production function; and (2-5) is a characteristic production function depicting how activities yield characteristics. To repeat, it is characteristics which provide satisfaction. Note that w_{jk} enters both eqs. (2-4) and (2-5). In (2-4)the important point is whether w_{jk} is present in at least the threshold quantity necessary to permit production of z_j, in (2-5), it is recognized

that, given that a z_j is produced, the amount of characteristics it provides depends upon the quantity of w_{jk} available for use in its production.

The level of satisfaction that the household enjoys may vary with full income, prices of purchased goods, wage rates, production technology, and the endowment of nonrival goods. Activity production technology in the form of human capital may be acquired by the household and may depreciate over time. The endowment of nonrival goods, e.g., atmospheric visibility, at any location is determined jointly by background conditions and the aggregate activities of mankind and thus may be influenced by public policy. By choice of location, the household may influence the endowment of nonrival goods available to itself.

Solution of the household's maximization problem yields implicit prices (or opportunity costs), π_m, for the various characteristics, c_m. Since these π_m depend on a particular household's activity production function and full income constraints, they are , in principle, different for each household. Furthermore, the π_m are affected by those factors that influence the household's activity production technology and its full income, the endowment of nonrival goods, and the price of purchased goods.

The conceptual model of the consumption process has a number of interesting attributes.

1. It recognizes both the role of time in the consumption process (eq. (2-4)) and the consumer's choice in allocating marginal units of time between work and nonwork activities (eq. (2-2)).
2. The role of activity production technology (eq. (2-3)) permits explanation of changes in consumption bundles in the absence of changes in tastes, prices of purchased goods, or endowments of nonrival goods.

A change in activity production technology (e.g., the acquisition of some specialized consumption or leisure skill) may be sufficient to change the π_m, c_m, and x_{jn}. Indicators of household activity production technology would be expected to prove useful in explaining variation in the WTP for W_k (e.g., atmospheric visibility) across households.

3. The two-step relationship between goods, activities and characteristics (eq. (2-4) and (2-5)) permits more complete understanding of the relationship between goods which are substitutes or complements in consumption, and the reasons why goods enter and exit the marketplace (Lancaster.) If it is charactertistics which are demanded, if various activities produce different (but, in some cases, overlapping) vectors of characteristics, and if changes in activity production technology change the amounts of the activities which may be produced from given quantities of purchased and nonrival goods, then the process by which changes in prices or activity production technology lead to substitution among activities and perhaps the total elimination of some activities may be completely understood. A set of general hypotheses may be developed along these lines, testable in specific natural resource and environmental contexts.

   Thus, the model incorporates the possibility of substitutes and complements for visibility. In the production of safety characteristics for aviation, navigation instruments may be excellent substitutes. In the production of view characteristics for valued vistas, the only available substitute, photographs taken by another at a time when visibility was better, may be quite poor substitutes.

4. These concepts may be used to more precisely define activity value, expected activity value, option

value, the expected activity value for the non-risk-neutral individual and existence value, In our context, if one or more valued characteristics may be derived from one or more activities which are produced using only w_k, their value is the pure existence value for w_k,

This model of the process through which the household derives satisfaction from a non-rival endowment such as ambient visibility is useful for several purposes:

- it permits the derivation of welfare impacts, in consumer's surplus terms, of changes in the endowment of a non-rival good, ambient visibility;

- in so doing, it provides a conceptual linkage between contingent valuation methods, analyses of behavioral choices, and valuation methods which use observations from the markets in goods whose demands are systematically related to the demand for visibility;

- it identifies the relevant categories of variables for use in bid equations to explain variation in individual WTP for improvements in ambient visibility, thus increasing the likelihood that regularities in WTP can be documented;

- with its focus on the role of nonrival endowments in the production of activities which yield satisfaction, it provides a conceptual focus for a major section of our research effort: analysis of the relationship between ambient visibility and the observed activity production behavior of individials. This research is a major, original contribution of our project. Previous projects have, for the most part, confined their attention to contingent valuation and the analysis of relationships between property values and ambient air quality (of which visibility is one characteristic).

2.2.2.2 Welfare Impact and Consumer's Surplus

The following model derives expressions for the consumer's surplus value of the welfare impacts of changes in the endowment of environmental goods. These expressions are conceptually straightforward but quite lengthy. So, for expository purposes, we will revert to a simpler model in this section in which utility is a function of the endowed level of nonrival amenity (ambient visibility) and a vector, $\underline{X}$, of ordinary, priced goods,

$$U = U(W,\underline{X}) \tag{2-7}$$

From this point, the valuation methods may be devised by either of two approaches.

1. The Income Compensation Function Approach

Define Y as the numeraire value of $\underline{X}$. The utility function, implicit in prices, $\underline{P}$, may then be represented as

$$U = U(W,Y) = U[\underline{P}(W,Y)] \quad , \tag{2-2}$$

where W is taken as initially fixed to the individual.

Using the income compensation function, $\mu(W|W^*,\bar{Y})$, which represents the least amount of the numeraire the individual would require with W to achieve the same level of utility as with W^* and $\bar{Y}$, a system of partial differential equations may be derived for various reference levels of W,

$$\frac{\partial \mu(W|W^*,Y)}{\partial W} = P[W,\mu(W|W^*,\bar{Y})] . \tag{2-9}$$

For a change in visibility from W' to W", where $U(W',\bar{Y}) < U(W'',\bar{Y})$, the Hicksian compensating measure of the welfare impact for the individual's willingness to pay (WTP), is

$$(2\text{-}10) \qquad WTP = \int_{W'}^{W''} P[W,\mu(W|W',\bar{Y})]dW.$$

An equivalent measure, the individual's willingness to accept (WTA), is

$$(2\text{-}11) \qquad WTA = \int_{W'}^{W''} P[W,\mu(W|W'',\bar{Y})]dW.$$

That is, both WTP and WTA are defined as areas under (different) Hicksian compensated demand curves for W. WTP and WTA may be directly observed using any technique which permits estimation of the respective indifference surfaces passing through

$$(2\text{-}12) \qquad \begin{aligned} &U'(W',\bar{Y}) = U'(W'',\bar{Y} - WTP), \text{ for WTP, and} \\ &U''(W'',\bar{Y}) = U''(W',\bar{Y} + WTA), \text{ for WTA.} \end{aligned}$$

Most contingent valuation (CV) methods, (including direct questions, checklist questions, iterative bidding, and various experimental formats) are designed to estimate (2-12). The theory is direct, undemanding in terms of the analytical assumptions needed, and easily applied. The most serious challenge in empirical application concerns data quality. Most CV methods are in principle susceptible to some kind of strategic behavior. WTP and WTA data may also be disturbed by outside influences. The principal challenge in implementation of CV methods is to minimize (1) opportunities for strategic behavior and (2) the incidence of noise in the data set.

2.2.2.3 The Expenditure Function Approach

An alternative formulation of the same problem posits the utility function (2-7), in which $\underline{X}$ is a vector $(x_1,\ldots,x_i,\ldots x_n)$ of ordinary, private (i.e., exclusive, divisible, and nonrival) goods. Maximizing (2-7) subject to a budget constraint, $\sum_i p_i x_i = Y^o$, generates a set of Marshallian demand functions,

$$x_i = X_i\ (\underline{P}, W, Y^o). \qquad (2\text{-}13)$$

The possibility that W is an argument in the demand for private goods (c.f. eq. (2-4) and (2-5)) suggests that market data, prices and quantities taken, for x_i may be used to reveal the welfare impact of changes in W. Let us explore this possibility. First, we establish the theoretical equivalence of the expenditure function and income compensation function approaches. Then, we consider the implementation of the expenditure function approach.

The utility maximization problem yields ordinary demand equation (2-13). The dual of the same problem minimizes expenditure, $\sum_i p_i x_i$, subject to the constraint that utility must be at least equal to some specified level, U. Solution to the problem

$$\min \sum_i p_i x_i$$

$$\text{s.t.} \quad U = U(\underline{X}, W)$$

yields the expenditure function. Considering a proposed change in the availability of a nonrival good from W' to W", where $U'(\underline{X},W') < U''(\underline{X},W'')$, the relevant expenditure functions are, respectively,

(2-14) $E'(\underline{P},W,U')$ and
$E''(\underline{P},W,U'')$.

The derivative of any expenditure function with respect to any price, p_i, yields a Hicksian compensated demand function for x_i. For the expenditure functions (14), the compensated demand functions are:

$$(2\text{-}15)\quad x_i^{h'} = \partial E'/\partial p_i = E'_{p_i}(\underline{P}, W, U') \text{ and}$$

$$x_i^{h''} = \partial E''/\partial p_i = E''_{p_i}(\underline{P},W,U'') \quad .$$

The inverse Hicksian compensated demand curves for W are given by

$$(2\text{-}16)\quad -\partial E'/\partial W = E'_w(\underline{P},W,U') \text{ and}$$

$$-\partial E''/\partial W = E''_w(\underline{P}, W, U'').$$

Thus, the compensating and equivalent measures of the welfare impact of the proposed change are respectively,

$$(2\text{-}17)\quad WTP = -\int_{W'}^{W''} E'_w(\underline{P},W,U')dW, \text{ and}$$

$$(2\text{-}18)\quad WTA = -\int_{W'}^{W''} E''_w(\underline{P},W,U'')dW.$$

Eq. (2-17) is, of course, equivalent to eq. (2-10) and similarly eq.(2-18) is equivalent to (2-11). This alternative formulation, however, offers the prospect of empirically estimating WTP and WTA without directly observing (relevant points on) indifference surfaces expressed in (W,Y) space. Instead,

under favorable conditions, it should be possible to estimate WTP and WTA via appropriate manipulation of readily accessible market data for private goods, x_i, expressed in forms suitable, initially, for estimating (2-13). A number of techniques have been developed to use this approach. Examples include methods which analyze travel costs, property values, and hedonic prices.

Let us now consider the conditions under which these various approaches may be effective.

2.2.2.4 Comparison of Approaches

a) Separable utility functions. If the utility functions is strongly separable in W, i.e.,

$$U(\underline{X},W) = U_x(\underline{X}) + U_w(W), \tag{2-19}$$

then the demand functions for x_i will all be of the form

$$x_i = x_i(\underline{P},Y), \tag{2-20}$$

that is, completely independent of the level of W. Certain commonly used functional forms for utility functions (e.g., the Cobb-Douglas and CES forms) have this property, and Freeman (1979) argues that some important classes of environmental amenities may in fact be separable. In such cases valuation methods based on the expenditure function approach are without prospects, and valuation will be performed with CV methods or not at all.

b) Nonseparability of x_i and W. In many cases, demands for x_i may not be spearable from W, as in eq. (2-13). If such a system of demand equations has been estimated and it satisfies the Slutsky conditions for integrability, it may be possible to solve for the underlying expenditure function. If it is, eq. (2-17) eq. (2-18) can be estimated and the value of W at the margin, of the welfare

impact of a nomarginal change from W' to W", can be estimated by implicit pricing methods. However, it is generally necessary to impose additional conditions on the problem in order to solve the system completely (Maler, 1974). Two, often benign, assumptions that are useful are (1) weak complementarity and (2) the existence of a perfect substitute.

Weak complementarity occurs if when the quantity of x_i demanded is zero, the marginal utility of W is zero (Maler, 1974). In such cases, when W increases the demand for x_i shifts out, and the value of W" - W' is approximated by the integral between $x_i(\underline{P},W'',Y)$ and $x_i(\underline{p},W',\bar{Y})$. This valuation approach can be operationalized as long as demand curves approximates the integral between Hicksian compensated demand curves (Willig, 1976; Randall and Stoll, 1980).

The assumption of weak complementarity provides the basis for the travel cost method of valuing recreation amenities (Clawson and Knetsch, 1966; Stevens, 1966) and the land value method of valuing increments in air quality, view quality, and other residential amenities (Freeman, 1974; Brown and Pollakowski, 1977). It should be noted, however, that Maler (1977) expresses doubts as to whether the weak complementarity assumption is satisfied in the housing market or (by extension) in other markets frequently used for implicit valuation of non-marketed goods.

A second approach is operational if we can suppose that some good x_i is a perfect substitute for W. If some x_i and W are perfect substitutes, while W and $\underline{X}^j$ (x_i is not in $\underline{X}^j$) are independent in the utility and demand functions, the marginal demand price of W reduces to the price of x_i multiplied by the substitution ratio between x_i and W (Maler, 1974; Freeman, 1979.

This idea suggests that if there exist some x_i which counteract the effects of pollution so that x_i are perfect substitutes for improvements in W, expenditures on x_i provide evidence of the value of W. If the elasticity of substitution between x_i and W is less than infinite, this method would underestimate the value of W. While this method has promise, we have yet to find published studies demonstrating its successful application in empirical research.

c) Hedonic Prices.

Assume first that x_i and W are not separable in the utility function. Second, assume that x_i can be defined in terms of a vector of characteristics $\underline{c}_i = (c_{i1}, \ldots, c_{in})$. Third, assume that a purchaser, j, of good x_i can vary $\underline{c}_i$ by choosing a particular unit, x_{ij}. That is, x_i is not the usual homogeneous good but a bundle of attributes as are houses and automobiles. Finally, suppose that one of the characteristics in $\underline{c}_i$ is c_{iw}, the amount of W enjoyed along with x_i. Therefore, as the consumer selects, for example, a given house or car, the amount of residential air quality he enjoys along with his house or the amount of safety he enjoys along with his car is also determined. For any unit of x_i, say c_{ij}, its price, $p_{x_{ij}}$, is

$$p_{x_{ij}} = p_{x_i}(c_{ij1}, \ldots, c_{ijw}, \ldots, c_{ijn}), \tag{2-21}$$

where p_{X_i} is the hedonic price function for x_i. If p_{X_i} can be estimated from observations of the prices $p_{X_{ij}}$ and the characteristics $\underline{c}_{ij}$ of different x_{ij}, then the price of any x_{ik}, $k \neq j$, can be calculated from a knowledge of

its characteristics. The implicit price of the characteristic, c_{ijw}, for individual j can be found by differentiation:

$$p_{c_{ijw}} = \partial p_{x_i} / \partial c_{ijw}. \quad (2\text{-}22)$$

Under favorable conditions, it is possible to use information in the implicit price function to identify the demand for c_{iw}, that is, the demand for W if W is enjoyed only as a characteristic of x_i. Assume the individual purchases only one unit of x_i (or, if more than one unit, only identical units) and the utility function is spearable in x_i and $\underline{x}^j$ (x_i is not in $\underline{x}^j$) so that the marginal rate of substitution between any pair of x_i is independent of $\underline{x}^j$. Then, depending on the form of the characteristic demand function (Rosen, 1974), it is possible to estimate the inverse demand curves for W. In such a case, the integral between the inverse demand curves for W' and W" would approximate the intetral between the appropriate Hicksian compensated demand curves (Willig, 1976; Randall and Stoll, 1980).

In the brief period since publication of Rosen (1974), many attempts to use hedonic prices to value nonmarketed goods have been initiated. Applications have included many aspects of residential amenities (e.g., airport noise, Abelson, 1979), and work place safety (Thaler and Rosen, 1975). An literature is emerging to identify and catalog the analytical difficulties this approach encounters.

The priminary advantage of methods which use the expenditure function apporach is data quality. Such methods use data sets of actual transactions. CV methods, by definition, will never enjoy that advantage. However, that does

not mean that the estimated values for W derived from expenditure function approaches are necessarily valid or, for that matter, superior to estimates using CV methods. When $\underline{X}$ and W are strongly separable in the utility function, these methods cannot be used. When (nonseparable) relationships between $\underline{X}$ and W are not of the most simple kinds, the analytical assumptions will be violated to a greater or lesser degree, with corresponding deleterious effects on the validity of the value estimates for W. Thus, while the data base is, in a sense, real, the stringent analytical assumptions necessary to derive the value of W from observations in the market for $\underline{X}$ provide more than enough opportunities for bias or noise to intrude. Our empirical research plan, therefore, provided opportunities for replication of value estimates with both CV methods and methods which use various expenditure function approaches.

2.2.2.5 Econometric Specification of the Model

Herein, let us explore the implications of the above model for the specification of econometric equations to explain individual WTP for y_k. The model implies that the satisfaction derived from a change in the ambient level of visibility will be influenced by:

(1)--the array of activities produced using visibility; the characteristics these activities provide; and the array of activities which do not use visibility as an input, but which provide (some of) the characteristics provided by visibility-using activities.

(2)--the prices of purchased inputs used in production of the activities discussed immediately above. Taking a long time horizon, one would also be concerned with the availability at a particular time of purchased inputs which may enter and/or exit the marketplace and with

changes in input quality. In the static time frame, these would not be considerations.

(3)--in a cross-section of households spatially arrayed across the land surface, the array of Y_k, endowments of nonrival goods, would be expected to vary; and this variation will influence the productivity of the activity production process. This suggests a focus on nonrival goods, in addition to air quality, which are used in production of visibility-using and nonvisibility-using activities which provide (some of) the same characteristics.

(4)--the marginal opportunity cost of time to the household.

(5)--the household's activity production technology in general and in particular as it applies to visibility-using activities and, non-visibility-using activities which provide (some of) the same characteristics. Technology can be expected to vary across households and one important subset of technology, the things that contribute to visual acuity, may vary within the household. In general, activity production technology may be acquired and many depreciate, which is important in a longitudinal time frame, but not in the static time frame.

(6)--the household's preferences across characteristics. Economics has made little headway in using information about preferences to explain individual household demand for purchased goods, or household valuation of nonrival goods. The revealed preference approach by-passed the fundamental question by taking it as axiomatic that purchases reveal preferences. Time-series analyses of demand often resort to the use of crude trend variables which are presumed to correct for secular changes

in tastes (and anything else which may not be properly accounted by the other, more precisely defined, independent variables). One could argue that a significant trend variable should lead to the rejection of the hypothesis that the model is adequately specified.

Becker has shown that, under certain plausible assumptions about caring within the household, the household acts as though it is seeking to maximize a single preference function. Stigler and Becker have argued that, since economics has made such poor positive use of the notion of preference (for the most part, being satisfied with negative uses such as using it as an all-purpose copout to explain away otherwise inexplicable results), progress might best be sought by assuming that preferences are constant across households and across time periods, thus ascribing behavioral differences to differences in opportunity sets and activity production technology.

If the above-mentioned factors influence the satisfaction derived from changes in the level of atmospheric visibility, WTP for these changes is influenced, in addition, by

(7)--household full income.

(8)--the competing demands within the household, which may influence the marginal and total WTP for characteristics that may or not be provided by visibility-using activities versus WTP for characteristics always provided by non-visibility using activities. If this latter group of characteristics is treated as a numeraire, then we are speaking of those things that influence the marginal rate of substitution between the numeraire and the group of characteristics that may or may not be provided by visibility-using characteristics.

In summary, eight cataegories of variables which may influence WTP have been identified. Of these, we may a priori assign low priorities to categories (2) and (6): (2) on the grounds that unit prices of homogenous purchased goods used along with visibility to produce characteristics are unlikely to experience much variation in a static cross-section; and (6) on the basis of the Stigler-Becker argument which suggests an emphasis on inter-household variations in activity production technology rather than preferences.

In the light of the preceding conceptual analysis, let us now consider the variables traditionally used to explain variations in individual WTP. To what extent do these variables capture precisely the kinds of factors thought to influence WTP? Are the traditional variables addressed to a single factor or to multiple factors. If to a single factor, is the underlying relationship clear, unambiguous and fully specified? If to multiple factors, are the various underlying relationships between these factors and WTP unidirectional. (If not, a priori expectations will be unclear, and the interpretation of results will be ambiguous.) Are there variables and relationships that the conceptual model suggests are likely of importance, but which are ignored by the traditional variables?

Below, the traditional variables are listed and for each, its interpretation in terms of the factors identified by the conceptual model is explored.

Traditional Variable	Category of Factors Influencing WTP
Income	--(7), i.e., income addresses the notion of "full income," but incompetely, since it ignores the relationships between current income, work and wealth.
Education	--(5), presumably, better education assists the acquisition of activity production technology (APT), but this relationship is unclear. Formal education may be of little use in the acquisition of outdoor APT's, and the time spent gaining it may have come at the cost of time which would otherwise be spent acquiring outdoor APT's. -- Education may be a better indicator of acquired technology useful in handling CV exercises.
Age	--(5), presumably. However, advancing age implies the depreciation of certain APTs while it may permit the acquisition of others. For specific APT's, the relationship between age and technology has yet to be conceptualized.
	-- if the program (e.g., to improve visual air

	quality) is seen as one which requires the passage of time, in order to achieve its full effectiveness, advancing age may indicate shorter time horizons (a problem our model does not explicitly address) or pessimism about the speed and effectiveness of program implementation.
Race/Ethnicity Sex	--(5), if R/E or Sex determines propensity to acquire certain APT's. Does it? Which ones? --(1), if overt or subtle descrimination removes some x's or z's from opportunity sets.
Household Size	--to some extent, an indicator of (8).
Unemployed	--(4), if it indicates a temporary change in the marginal opportunity cost of time. If unemployment is voluntary, it indicates something more permanent about the respondent's MOC of time. --(7), temporary change in full income. --(5), if unemployment frees up time for the acquisition of APT's.
Rural/Urban	--(3), a crude indicator. --(5), if R/U residence indicates something

about opportunities to acquire APT's. In this context R/U for the first two decades of life may be a better APT indicator than current R/U residence.

--(1), perhaps some x_s are available in R but not U, as vice-versa.

*--Unfortunately, R/U may indicate different beliefs about the state of nature with respect to markets in environmental goods: R may feel environmental goods should be free and available in virtually unlimited quantities, while U may not object to paying for restricted quantitives.

Location of residence

--(3), perhaps a little better indicator than R/U. However, location is unlikely to identify all of the respondents enjoying a particular Y_k.

--(5), e.g., Florida residence increases the travel component in the activity production function for downhill skiing.

--(1). Maybe some x's are unavailable in some localities.

*These are considerations of how effectively a respondent uses a CV instrument to reveal his true WTP, not the value of his true WTP.

Water/Fish/Swim/Boat (From RFF water quality instrument)	--(5). However, it is crude, since it fails to distinguish among e.g. different fishing APTs. (A sociologist has identified 5 classes of trout fishermen; perhaps he means people possessing 5 categories of trout fishing APTs.)
Walk along the Ridge? (From U.C. Indiana Dunes instrument)	--(5); but, which APT's? --(4), maybe: Marginal opportunity cost of time is low enough to permit walking.
Binoculars? (From U.C. Indiana Dunes instrument)	--(5)? Actually, it indicates the decision to purchase a specific x.
Environmentalist	--(6), an "attitude" to the sociologist. --(5), to a Stigler-Becker economist. But which APT's do respondents associate with the word "environmentalist? (After all, it is self-reported?)

To summarize, these traditional variables provide the following qualities of information in each of the 8 categories:

(1) Almost nothing. Every variable which may be interpreted in terms of (1) has at least one other interpretation. None is yet specific to any particular category of x's, z's, or c's.

(2) Nothing about input prices, but in a static, cross-sectional variation in input prices may not be especially significant.

(3) Very little. Only R/U and Location address this issue, and both are very blunt proxies.

(4) Very little. Only Unemployment and "Walk along Ridge?" address this issue. The Latter, especially, is blunt.

(5) Several variables may address APT, but none is capable of addressing specific categories of APT's precisely and to the exclusion of other APT's.

(6) If you believe Stigler-Becker, (6) is a dead-end street, anyway.

(7) Income is addressed in money terms, but not full income terms.

(8) Only Household Size addresses (8), but it is a blunt indicator.

Further, many of the variables lack any clear a priori expectation as to the sign or magnitude of the coefficient, and any clear interpretation of empirical results in term of the conceptual model. This occurs in the cases of variables which say address two or more of the categories, and variables which address, e.g. category (5), but in no clearly-conceived my (e.g. Education, Age, R/E, R/U).

2.2.2.6 Review and Summary

The discsussion thus far suggests that many previous CV exercises may have encountered at least some of the following problems (or, at least, may have been suspected of being susceptible to some of them):

1. Strategic bias: There is agreement that scope for strategic bias exists but little evidence to suggest that strategic behavior is prevalent.

2. Conservative/cautious initial response. That is, the kind of unsure and unconfident initial reaction to new and radically different hypothetical markets which may be the cause of WTP understatements noted by Bishop and Heberlein.

3. Unsatisfactory bid equations.

a. small samples.

b. bids, themselves, may be poor quality data.

(i) the good being bid for may be incompletely perceived, or perceived differently across respondents.

(ii) respondents may have difficulties arriving at what is, for them, the optimal bid.

c. poor specification of bid equations.

(i) independent variables poorly defined.

(ii) independent variables imprecisely measured.

(iii) poor selection of independent variables, resulting from inadequate conceptualization of the process through which environmental goods acquire value.

Of the 8 categories of variables which the conceptual model suggests as likely to influence WTP for atmospheric visibility, five seem especially important. Let us consider these five categories of variables, attempting to identify and define variables appropriate for observation and use in WTP equations.

Full Income (7): Annual value of household consumption is important, i.e., annual household disposable income corrected for saving or dissaving. However, gross annual household income is most readily observed. Also important is net worth, since especially in higher age groups, consumption is financed in part by dissaving.

Marginal Opportunity for Cost of Time (4): The expected wage rate for one additional hour of work weekly is important. The question must be worded carefully, to ensure that respondent does not interpret it to mean "the reservation price for an additional hour of work."

Competing Demands on the Household Budget (8): Household size is important. It is also desirable to know the life cycle stage of the household (young children, college students, aged dependents, etc.).

Endowments of Nonrival Goods (3): Of particular importance is the definition of bundle of nonrival goods available for consumption jointly with atmospheric visibility.

a. big city/town/rural non-farm/farm.

b. coastal/mountains, hills/flatlands.

c. some indication of the variety and aesthetic quality of the vistas encountered in the course of normal activity (at home, at work, commuting, shopping, local recreation). Secondary evaluation based on, say, zipcode, is not good enough, since within a locality different residential addresses, workplaces, and patterns of activity will lead to different view exposures. More satisfying than secondary evaluation is the self-reported subjective evaluation, e.g. "in course of a typical week, would you say that the most attractive view to which you are regularly exposed are: spectacular? more pleasant views than most folks get to see regularly? ordinary views? worse than ordinary?

In a study-region-wide sample, it is useful to know whether the respondent is concerned primarily with his own locality, or whether his concern is geographically broader.

d. Do you expect to live here for the indefinite future?

or, do you expect you might move to a place selected because, among other reasons, it is scenically attractive?

or, do you expect you might move, but the decision would be unrelated to scenic concerns?

e. Do you usually vacation

--at home?

--at a place where

--you spend most of the time indoors?

-- . . . . . outdoors, urban?

-- . . . . . outdoors, rural?

-- . . . . . outdoors at a place chosen.

among other reasons,for its scenic vistas?

Seasonal aspects of WTP for visibility, climatic aspects (temperature, cloud cover, snowfall, etc.--secondary data) are of interest in analyzing a broad cross-sectional sample.

Activity Production Technology (5): Activity production technology may, in concept, be observed directly,or indirectly via observation of purchased goods used (x's), activities produced (z's), or characteristics enjoyed (c's).

a. Direct observation of APT's.

--visual acuity (is it "too much" to ask respondent to submit to a simple eyesight test?).

--powers of observation: in the evening, if asked, do you think you could accurately describe visibility conditions during the preceding daylight hours?

--knowledge of what is being viewed:--identification of features of scenes, e.g. animal/bird/plant species, distant objects, geological formations, etc.

--identification of location of U.S. scenes represented in photographs.

--health and physical fitness (self-reported? enumerator evaluated?).Presumably this is a major element in APT's for vigorous outdoor activities which use visibility as an input.

--acquired skills: do you hold a pilot's license? have you ever been recognized (e.g. by winning a prize or selling your work) for landscape painting or photography? do you feel confident doing the following things: rock climbing or mountaineering; hiking through the back country; taking a good landscape photograph; walking/running/bicycling long distances; cross-country skiing?

b. z's produced

--list them all (data overload)

--indicate if you regularly engage in any activities in the following categories:

strenuous outdoor	--rural scenic (examples: hiking, biking, backpack).	
	--urban scenic.	
	--non-scenic (examples: tennis, team sports).	
other outdoor	--rural scenic (examples: picnicking, sunbathing, flying, driving to enjoy scenery).	
	--urban scenic.	
	--non-scenic.	
indoor view-oriented	--looking out the window.	
	--looking at collections of landscape photography.	

c. x's bought

--binoculars, cameras with telescopic lenses.

--equipment for activities which use visibility as an input (it could be a long list).

d. c's provided: Probably not much of value can be gained by getting a list of the visibility related characteristics from which respondents, derive satisfaction.

Visual. characteristics probably serve two purposes: (1) a source of aesthetic pleaure, and (2) an indicator of the health and comfort related aspects of air quality. Since it is important to isolate the visibility affects from the health and comfort affects, it may be useful to ask: indicate on this list the things you associate with atmosphere conditions depicted in the (worst case) set of photographs (list includes respiratory distress, poor color contrast, eye irritation, poor long distance visibility, poor ventilation in homes, etc. in addition to "placebo" and "decoy" items).

2.2.3 Strengths and Weaknesses of Contingent Valuation

For more than a decade contingent markets have been used to elicit individual valuations of unpriced (usually, nonrival and/or nonexclusive) goods and services. The basic idea is that the researcher constructs a model market in considerable detail and, in a survey or experimental setting, communicates the dimensions and characteristics of that market to the subject. The researcher specifies an increment (or decrement) in some good or service and invites the subject to make a conditional dollar-valued offer to buy (sell) the increment (decrement). The conditional offer is contingent on the existence of the model market as structured and communicated to the respondent; hence, the term contingent valuation. However, the exercise does not involve the actual exchange of goods and services for money.

Contingent valuation has several advantages, which seem likely to encourage its more general use. (1) Contingent markets may be inexpensively constructed and used by subjects (see, e.g., the argument of Brookshire and Crocker, 1981). Market structure and rules, and the quantity and quality dimensions of the good or service involved, may easily be manipulated in a conscious experimental design strategy; and such manipulations need not be limited to the currently observed range of market rules and quantities/qualities. (2) Contingent market data are generated in forms consistent with the theory of welfare change maeasurement (Bradford, 1970; Randall, Ives and Eastman, 1974; Brookshire, Randall and Stoll, 1980). (3) Contingent markets do not rely on the actual delivery of goods and services. Thus, their use is not limited to cases in which delivery is feasible and convenient to the researcher.

Other candidate techniques for valuation of unpriced goods do not enjoy all of these advantages. Indirect methods of inferring value data by observing actual markets in related goods (e.g., the travel cost, land value, and hedonic methods) have considerable failings with respect to points (1) and (2) above. The theoretical difficulties implicit in the restricitive assumptions required to yield value estimates from these kinds of observations should not be underestimated. Experiments with actual markets for exclusive but not customarily marketed goods may sometimes be contrived (Bishop and Heberlein, 1979). Perhaps more opportunities exist for incentive-compatible (Groves and Ledyard, 1977) laboratory experiments in which groups of subjects contribute toward the purchase of collective (i.e., nonexclusive and often, nontival) goods. However, these kinds of methods are adaptable for value-revealing purposes (as opposed to work with induced preferences, see Smith, 1977 and 1980) only in cases when the direct and side payments can be actually collected and the collective goods actually delivered--a restrictive condition.

The discussion thus far suggests that, if contingent valuation methods were generally accepted as accurate, there would be little reason to use other kinds of valuation methods in benefit cost analyses of programs that provide unpriced goods. However, it has generally been assumed from the outset that the accuracy and reliability of contingent valuation methods is minimal. Two blanket criticisms were raised: (1) “everybody knows” that hypothetical questions rarely enjoy accurate responses; and (2) “everybody knows” that where nonexclusiveness or nonrivalry are involved, strategic behavior is general, and the data collected are nothing but the pooled products of individual attempts to mislead the researcher.

In spite of the pervasive skepticism engendered by these sweeping criticisms, there has accumulated a body of evidence to the effect that considerable real information can be generated in contingent markets. In early applications, Davis (1963) and Randall, Ives and Eastman (1974) obtained results which were plausible and which did not fail certain (rather minimal) validation tests. The results of the last-mentioned study were later replicated by Brookshire, Ives and Schulze (1976) and Rowe, d'Arge and Brookshire (1980). Starting with Knetsch and Davis (1966) recreation demand analysts have consistently demonstrated comparability between the results of contingent valuation and travel cost methods. More recently, Brookshire et al. (1982) have demonstrated considerable consistency between results of hedonic analysis and contingent valuation.

Individual willingness to pay for nonexclusive or nonrival goods, as revealed in contingent markets, exhibits some regularities. Many researchers have found the theoretically expected relationships between individual bid and income (among others, Brookshire, Randall and Stoll, 1980; Mitchell and Carson), quantity of the good offered (Brookshire, Randall and Stoll, 1980) and the availability of substitute goods (Majid, Sinden and Randall). Socio-demongraphic and attitudinal variables are sometimes significantly related to bid (Brookshire, Randall and Stoll, 1980; Mitchell and Carson). These variables seldom account for a large proportion of the variance in individual bids. However, when individual observations are grouped in some way, to reduce the influence of outlying observations, much of the variance in bids across groups can be explained[1] (Brookshire, Randall and Stoll, 1980).

Nevertheless, some reasonable doubts about the accuracy and reliability of contingent valuation persist. (1) The possibility has been raised that

contingent markets in general, or in particular formats may be susceptible to various biases. This line of thinking leads to a cataloging of potential biases and empirical testing to determine the presence if any of the identified biases in particular data sets[2] (Brookshire, Ives and Schulze, 1976; Rowe, d'Arge and Brookshire, 1980; Schulze, d'Arge and Brookshire, 1981). Some of these biases are merely problems to which all survey research is susceptible, and sound research procedures are routinely available for their avoidance (e.g., sampling and interviewer biases). Others are more interesting: "strategic bias," "hypothetic bias," "starting point bias," and "information bias." However, there is nothing compelling about the taxonomy developed by Brookshire and his associates. Grether and Plott (1979) develop a quite different taxonomy, in an attempt to explain apparent preference reversal; and Mitchell and Carson quarrel with several aspects of the Brookshire et al. discussion.

"Strategic bias" is fairly clear. It provides the basis for the mainstream economic analysis of nonexclusiveness and nonrivalry; and it is strategic bias the incentive-compatible mechanisms (Groves and Ledyard, 1977) are designed to thwart. The basic idea is that when the consequences of truth-telling are more costly to the individual than those of some prevaricating stretegy, truth-telling inevitably gives way to strategizing. Since most contingent markets provide disincentives for free-riding, the most likely strategy is for an individual to bid in a way which exaggerates the difference between his true bid and his expectation of the sample mean bid, so as to move the sample mean bid toward his true bid. Pervasive behavior of this kind would increase the variance of a sample of bids, in the extreme producing a bimodal distribution. Given a minimum acceptable bid of zero (for

an increment in a positive-valued good) but no a priori maximum limit, such behavior would bias sample mean bids in an upward direction.

"Information," "starting point" and "hypothetic" biases are not so clear. In the hands of Grether and Plott (1979) these concepts merge to become Theory 8: the notion that, in the absence of good reasons to care about the consequence of their responses, subjects minimize investment in information processing and decision making by clutching at any "anchor" provided in the question format. As it turned out, Grether and Grather and Plott experimentally rejected Theory 8 by finding that introducing real incentives (reasons to care about consequences) did not diminish apparent preference reversal. In contingent valuation, there is little evidence of the general occurrence of "information" and "starting point" bias. Rowe, d'Arge and Brookshire (1980) claim to have found both kinds of bias in a single data set, but that finding appears to be the exception rather than the rule. The interpretation of "information" bias is controversial, since significant changes in the information provided to respondents must change the quantity/quality definition of the good being offered or the structure of the contingent market. Thus, a finding that changes in information generate changes in bids can seldom be unambiguously interpreted as a finding of bias. Often, it shows a rational response to a change in the situation posited, and provides more reason for comfort than alarm.

While Schulze, d'Arge and Brookshire (1981) argue that "hypothetic" and "strategic" biases are opposite sides of the same coin--contingent markets which give subjects less reason to care are susceptible to "hypothetic" bias while those that offer more reason to care are susceptible to strategic influences--Mitchell and Carson attempt a more subtle distinction. They

suggest that both kinds of bias can be simultaneously minimized by constructing realistic contingent markets but reassuring subjects that actual bids will not be collected during the experiment.

"Hypothetical bias," if it occurred, would increase the variance of bids. Given a lower limit of zero for acceptable bids but no upper limit, its influence would also be in the direction of overestimating true sample mean bid.

(2) A second attack on the efficacy of contingent markets focuses directly on the size of the value estimates obtained. Mitchell and Carson appear to be stating that conventional wisdom when they claim that contingent markets generally overestimate the true sample mean value of the nonexclusive and/or nonrival good under consideration. However, there is surprisingly little evidence to support this position. Bohm (1972) found a small upward bias when payemnts were hypothetical, but Mitchell and Carson question his interpretation of the evidence. Babb and Scherr (1975) found no evidence of bias in either direction. Brookshire et al (1982), in a comparison of hedonic and contingent valuation results, found good correspondence. A close examination of their analysis suggests that, if the contingent valuation results deviate at all from the true values, that deviation is almost surely on the downward side. Bishop and Heberlein (1979) compared contingent valuation results with those of a willingness-to-sell experiment in which actual exchange was consumated. They reaffirmed that contingent willingness to sell (in situations where selling is not customary or morally acceptable in the real world) leads to substantially larger value estimates than contingent willingness to pay--a well-established finding. Of more interest, they also found that contingent willingness to pay yielded considerably lower value estimates than actual willingness to sell--a finding which they interpret as showing that contingent WTP substantially underestimates true value.[4]

The evidence seems to suggest that the conventional wisdom is unsupportable. There is almost no evidence that contingent WTP overestimates true value, but there is some evidence to suggest underestimation.[5]

(3) A third source of doubts about the efficacy of contingent markets focuses not on mean sample bid but on the frequency of extreme bids. Starting with Randall, Ives and Eastman (1974) researchers routinely separate “protest bids” (that is, those zero WTP on infinite willingness to accept, WTA, bids which the subject identifies as a protest against some aspect of the contingent market structure) from the sample of bids prior to calculating the sample mean value estimate. The frequency of protest bids in various contingent markets has ranged from less than ten percent of all bids to more than fifty percent (Mitchell and Carson); so, it appears that the structure of contingent markets influences the quality of data obtained. While the literature contains less discussion of “high bids," most researchers find a few scattered respondents bidding a substantial fraction of annual income for increments in a single nonexclusive or nonrival good. While there exists no perfect test for strategic bids, most researchers take one of the following two courses: reject all bids above some arbitrary maximum, expressed as a dollar amount or a fraction of annual income; or reduce all high bids to the arbitrary maximum. The first approach arbitrarily treats all high bidders as dissemblers. The second grants some plausibility to high bids and, rather than disenfranchising high bidders, seeks to limit their influence on the sample mean bid. While we can be less certain that high bids are poor-quality data than we can about protest bids, contingent valuation researchers tend to treat both kinds of bids as unreliable and focus

their analysis on those bids which are identified as neither protest bids nor “too high."

This approach, incidently, parallels Smith’s (1980) discussion of his experiments, in which he treats zero-bidders as free-riders and endowment bidders as anti-free-riders (p. 396).

Let us attempt a very brief summary of what is now known about contingent markets.

1. Contingent markets are not incentive-compatible, but strategic behavior does not seem to be pervasive among human beings asked to contribute toward providing collective goods (Marwell and Ames, 1974; Smith, 1980; Sweeney, 1973). That does not mean that strategic behavior never occurs, just that there appears to be a substantial class of decision contexts in which a good many people do not behave strategically.

2. Contingent markets do not deliver the goods and collect the payments, but that does not necessarily render them wildly unreliable. The data sets collected via contingent valuation have, for the most part, performed fairly well in those quality tests which have been applied to them. This finding is consistent with the result of Grether and Plott (1979), who found that the introduction of real consequenses for their subjects did little to change decisions those subjects made in experimental contexts.

3. Contingent markets collect some “junk data”: protest bids, for sure, and presumably some of the high bids. However, they appear to collect a solid core of serviceable value data. These findings are entirely consistent with Smith’s (1980) experimental results.

4. Analyzing this solid core of serviceable data, we find no evidence that it consistently overestimates true value. If anything, the evidence

points to underestimation. In addition, individual bids are to some extent regular and predictable. In short, the solid core of data generated via contingent markets is neither fanciful nor random.

5. The structure of contingent markets does appear to have some (perhaps limited) influence on the value data generated. This ought not be surprising in principle--the performance of real-world and actual-experimental markets is influenced by their structure--but it is an appropriate subject for further investigation.

The remainder of this section reports some preliminary results of an experiment designed to explore two aspects of market structure: (1) the number of distinguishable commodities offered for bid and the sequence in which offered, and (2) the process in which bid data rea collected.

An extensive contingent valuation pilot study for the visibility project was consciously designed to permit, inter alia, experimental testing of the effect of contingent market structure on the characteristics of the bids generated. The general objective was to empirically explore the two apects of contingent market structure identified in the preceding paragraph. We proceed as follows. A conceptual framework is developed and specific empirically testable hypotheses are generated there from. Data collection procedures are briefly described. Analytical procedures consistent with the conceptual framework are introduced and used in hypothesis testing. Some preliminary results are presented and briefly discussed.

2.2.4 Conceptual Framework for Contingent Valuation

Consider a household which at any time is producing a simple activity γ_i selected from the vector $\underline{\gamma}''[\gamma_i]$. Its activity production function is

$$(2\text{-}23) \qquad \gamma_i = \gamma_i(\underline{\chi}_i, q_i, \alpha), \quad 0 = \gamma_1(0, q_i, \alpha),$$

where $\underline{\chi}_i$ is a vector of priced goods with prices $\underline{p}_i$, q_i is an unpriced nonrival good and α is the household's activity production technology. If π_i is the probability that the household is producing γ_i, and i is limited for convenience to the values 1, 2 and 3, and y refers to other goods, the indirect utility function is

$$(2\text{-}24) \qquad v(p, q, \pi, \alpha, m) = \max u(\pi_1 \cdot \gamma_1 + \pi_2 \cdot \gamma_2 + \pi_3 \cdot \gamma_3, y)$$

$$\text{subj. to} \quad y + \sum_{i=1}^{3} \underline{p}_i \chi_i = m,$$

$$\text{and} \qquad \gamma_i(\chi_i, q_i, \alpha) = \gamma_i \quad .$$

Using duality and the expected utility property,

$$(2\text{-}25) \qquad c(p, q, \pi, u) = \min y + \sum_{i=1}^{3} \underline{p}_i \underline{\chi}_i$$

$$\text{subj. to} \quad \sum_{i=1}^{3} \pi_i \, u[\gamma_i(\underline{\chi}_i, q_i, \alpha), y] \quad .$$

Letting the utility function be specified such that $\partial u / \partial \underline{\chi}_i \big|_{\underline{\chi}_i = 0} < \infty$, there may exist prices $\underline{p}_i$ at which the household would choose to set $\underline{\chi}_i$ and γ_i equal to zero.

With the expenditure function defined, consider a change in the level of provision of nonrival good[6] q_i.

(2-26) $$\partial e/\partial q_i = -\gamma \pi_i \partial u/\partial \gamma_i \cdot \partial \gamma_i/\partial q_i$$

$$= \delta_i(p, q, \pi, \alpha, u) \leq 0 \quad .$$

While the conceptual framework for contingent valuation is often derived via an income compensation function approach (section 2.2.2.2), it is possible to proceed via the expenditure function. For the moment, suppress α (which is used below in the empirical analysis) and π (which is of more interest in analyses explicitly directly toward option price, (see Schmalensee, 1972, and Graham, 1981), so that

$$e(p, q, u) = e(p, q, \pi, \alpha, u).$$

At an initial situation (p°, q°), the household requires $m^\circ = e(p^\circ, q^\circ, u^\circ)$ to attain u°. If the level or provision of a single environmental good q_i changed to q_i', the minimum expenditure to attain u° would be

$$m' = e(p^\circ, q', u^\circ) \quad .$$

The welfare impact of that change, in compensating surplus terms (Randall and Stoll, 1980) is

(2-27) $$CS(q_i^\circ, q_i') = e(p^\circ, q', u^\circ) - e(p^\circ, q^\circ, u^\circ)$$

$$= e(p^\circ, q', u^\circ) - m^\circ \quad .$$

Locating $e(p^\circ, q, u^\circ)$ in the real plane with (p°, m°) as the origin, $e(p^\circ, q, u^\circ)$ describes the indirect version of the familiar Bradford (1970) bid curve.

Now consider in all three nonrival environmental goods, i = 1, 2, 3. For clarity, we express $q = (q_1, q_2, q_3)$ as

$$e(p, q, u) = e(p, q_1, q_2, q_3, u) .$$

For a change from $q^\circ = (q_1^\circ, q_2^\circ, q_3^\circ)$ to $" = (q_1', q_2', q_3')$,

$$(2\text{-}28) \quad CS(q^\circ, q") \equiv e(p^\circ, q", u^\circ) - e(p^\circ, q^\circ, u^\circ)$$

$$= \int_{q^\circ}^{q"} \partial e(p^\circ, q_1, q_2, q_3, u^\circ) / \partial q \, dq ,$$

$$C(q)$$

where C(q) denotes some path from q° to q".

Choosing a particular rectangular path from q° to q", say $(q_1^\circ, q_2^\circ, q_3^\circ)$ to $(q_1', q_2^\circ, q_3^\circ)$ to (q_1', q_2', q_3°) to (q_1', q_2', q_3'), the line integral (2-28) can be transformed to the sum of several ordinary integrals,

$$(2\text{-}29) \quad CS(q^\circ, q") \equiv e(p^\circ, q", u^\circ) - e(p^\circ, q^\circ, u^\circ)$$

$$(2\text{-}29.1) \quad \equiv \int_{q_1^\circ}^{q_1'} \partial e(p^\circ, q_1, q_2^\circ, q_3^\circ, u^\circ)/\partial q_1 dq_1$$

$$(2\text{-}29.2) \quad + \int_{q_2^\circ}^{q_2'} \partial e(p^\circ, q_1', q_2, q_3^\circ, u^\circ)/\partial q_2 dq_2$$

$$(2\text{-}29.3) \quad + \int_{q_3^\circ}^{q_3'} \partial e(p^\circ, q_1', q_2', q_3, u^\circ)/\partial q_3 dq_3 .$$

An alternate rectangular path from $(q_1^\circ, q_2^\circ, q_3^\circ)$ to $(q_1^\circ, q_2^\circ, q_3^\circ)$ to (q_1°, q_2', q_3') to (q_1', q_2', q_3') results in the same aggregate valuation as in (2-29):

$$(2\text{-}30) \quad CS(q^\circ, q") \equiv e(p^\circ, q", u^\circ) - e(p^\circ, q^\circ, u^\circ)$$

$$(2\text{-}30.1) \quad \int_{q_1^\circ}^{q_1'} \partial e(p^\circ, q_1, q_2', q_3', u^\circ)/\partial q_1 dq_1$$

(2-30.2) $$+ \int_{q_2^\circ}^{q_2'} \partial e(p^\circ, q_1^\circ, q_2, q_3', u^\circ)/\partial q_2 dq_2$$

(2-30.3) $$+ \int_{q_3^\circ}^{q_3'} \partial e(p^\circ, q_1^\circ, q_2^\circ, q_3, u^\circ)/\partial q_3 dq_3$$

However, unless $\partial^2 e/\partial q_i \partial q = 0$, (249.1) $\neq$ (2-30.1), (2-29.2) $\neq$ (2-30.2) and (2-29.3) $\neq$ (2-30.3). Thus, we have

Proposition 1: The contribution of an increment in a single q_i to the value of an increment in the q vector from q° to q" varies with the sequence of valuation, unless $\partial^2 e/\partial q_i \partial q_j = 0$.

Further, if $\partial^2 e/\partial q_2 \partial q_1 > 0$ and $a^2 e/\partial q_3 \partial q_1 > 0$ (i.e. q_1 and q_2, and q_1 and q_3 are substitutes[7]) the contribution of q_1 to the value of an increment in the q vector will be greater, the earlier q_1 appears in the valuation sequence.

Identities (2-29) and (2-30) suggest that, in general, it is erroneous to value a change from q_i° to q_i' and a change from q_j° to q_j' independently and then calculate the value of a simultaneous change from $[q_i', q_j']$ by simple addition. Suppose q_1, q_2, and q_3 are substitutes. If we were to proceed as if the valuations of the individual changes were independent, we would measure

(2-31) $$V(q^\circ, q'')$$

(2-31.1) $$= e(p^\circ, q_1', q_2^\circ, q_3^\circ, u^\circ) - e(p^\circ, q_1^\circ, q_2^\circ, q_3^\circ, u^\circ)$$

(2-31.2) $$+ e(p^\circ, q_1^\circ, q_2^\circ, q_3^\circ, u^\circ) - e(p^\circ, q_1^\circ, q_2^\circ, q_3^\circ, u^\circ)$$

(2-31.3) $$+ e(p^\circ, q_1^\circ, q_2^\circ, q_3', u^\circ) - e(p^\circ, q_1^\circ, q_2^\circ, q_3^\circ, u^\circ) .$$

A well-conceived valuation would recognize the non-independence of q_1, q_2 and q_3 select a policy path (for example, the path in eq. (2.29)), and obtain

$$(2\text{-}32) \qquad CS(q^\circ, q'') \equiv e(p^\circ, q'', u^\circ) - e(p^\circ, q^\circ, u^\circ)$$

$$(2\text{-}32.1) \qquad \equiv e(p^\circ, q_1', q_2^\circ, q_3^\circ, u^\circ) - e(p^\circ, q_1^\circ, q_2^\circ, q_3^\circ, u^\circ)$$

$$(2\text{-}32.2) \qquad + e(p^\circ, q_1', q_2', q_3^\circ, u^\circ) - e(p^\circ, q_1', q_2^\circ, q_3^\circ, u^\circ)$$

$$(2\text{-}32.3) \qquad + e(p^\circ, q_1', q_2', q_3', u^\circ) - e(p^\circ, q_1', q_2', q_3^\circ, u^\circ) \ .$$

In (2-31) and (2-32), only lines (2-31.1) and (2-32.1) are equal. In the case of substitutes, (2-31.2) is larger in absolute value than (2-32.2) and (2-31.3) is larger in absolute value than (2-32.3). Thus we have

Proposition 2 : If $\partial^2 e/\partial q_i \partial q_j \neq 0$, the value of a change in the vector q is not equal to the sum of the independently estimated vales of the changes in the elements of the vector.

Further, if $\partial^2 e/\partial q_i \partial q_j > 0$ for all $i \neq j$, the value of a change in the vector q is less than the sum of the independently estimated values of the independently estimated values of the changes in its elements.

By identifying appropriate valuation and aggregation procedures, (2-29), (2-30) and (2-32) provide important restricitons on the design of contingent valuation exercises.[8] In addition, they provide an explanation for phenomena observed but not well explained in previously reported contingent valuation studies (e.g., Schulze et al., 1981b; and Walsh et al., 1978). In these studies, authors report with some surprise that environmental goods valued later in a valuation sequence are not valued as highly as had been predicted.

Competitive and complementary relationships arising from price changes are frequently observed. It is important to consider the possibility that competitive and complimentary effects are absent or weak for changes in non-rival goods. A possibility is the case where non-rival goods are additively separable in the utility function. In this case, Proposition 1 applies. Let preferences of an individual be represented by an additively separable utility function,

$$u = \sum_{i=1}^{I} \sum_{k=1}^{K} v_i(x_k, q_k) \quad ,$$

where $x_k=(x_{kg})$ is a G-dimensional vector of market goods, $q_k=(q_{kh})$ is an H-dimensional vector of non-rival goods, $k\varepsilon\{1,...,K\}$ indexes subcategories of market and non-rival goods used in v_i, the v_i are each increasing and strictly concave with non-negative second-order cross partial derivatives, and $\partial q_k/\partial q_f=0$ for $k\neq f\varepsilon\{1,\ldots,K\}$. Let

$$e(p,q_1,\ldots,q_K,u) = \min_x px \quad \text{s.t. } u = \sum_{i=1}^{I} \sum_{k=1}^{K} v_i(x_k, q_k) \quad .$$

Then the following properties hold:

(1) For non-rival goods in different subcategories ($k \neq f$) the substitution relationship is competitive ($\partial^2 e/\partial q_{kh}\partial q_{fr}>0$, all h and r).

(2) For non-rival goods in the same subcategory the substitution relationship may be either competitive, independent, or complementary ($\partial^2 e/\partial q_{kh}\partial q_{kr} \gtrless 0$, all h and r).[9]

Proposition 1 demonstrates that independence in valuation does not arise from additive separability. Indeed, the case of additive separability between non-rival goods results in unambiguous competitive effects.

Where additive separability cannot be assumed, competitive and complementary effects are both possible. Complementary effects may outweigh competitive effects. Less likely is the case where competitive and complementary effects just cancel and result in independence in valuation.

Given the implications of Proposition 1 it is useful to consider the empirical circumstances that may justify additive separability between non-rival tools. Below, we examine two possible cases: the first where an individual enjoys equivalent activities each affected by different sets of non-rival goods and the second where future use is uncertain. These illustrative cases are easily linked to common benefit cost contexts. Thus interpreted, Proposition 1 provides an a priori prediction of competitive effects.

Consider the first case where the household production technology for activity i is not specific to a particular site or region k. Market goods $x_{k'}$ and non-rival goods $q_{k'}$ available at site or region k, enter as inputs into the production technology and $a_{ik}=a_i(x_{k'},q_k)$ Within a given time period total activity production of type a_i is a simple summation over all visited sites or regions k, $a_i=\sum_{i=1}^{k} a_i(x_k,q_k)$. If preferences are defined over a similar time period (say, a month or a year) utility can be written

$$u = u[a_i, a(x,\omega)] \tag{2-33}$$

$$= u[\sum_{i=1}^{K} a_i(x_k,q_k), a(x,\omega)] ,$$

where a(.) is a vector of other activities, x is a vector of market goods, and ω is a vector of non-rival goods specific to a(.). If activities a_i are broadly defined and do not directly and strongly affect the enjoyment of other activities ($\partial^2 u/\partial a \partial a_i = \gamma$ (a constant)), then utility is approximated by

$$u = \sum_{i=1}^{K} a_i(x_k, q_k) + \gamma' a(x, \omega) \quad , \tag{2-34}$$

where γ is a vector of ones conformable to $a(x,\omega)$. On grounds of convenience, additive separability as in eq. (2-34) is a common assertion in both economic theory and econonometrics (Deaton and Muelbauer). Moreover, in this case of equivalent activities over different sites or regions, additive separability has strong intuitive appeal. For instance, enjoyment of slack-water recreation at site k is not likely to be directly affected by water quality at site m; snowskiing activities at site n are not likely to be directly affected by the slopes available at site p.[10]

A second source of dominating additivity comes from the rationale underlying option demand and option price. Consider a simple case where an individual faces the future possibility of either recreating within the region of residence or visiting one of two unique but distant recreation areas. By unique we mean that activity production technology is peculiar to the recreation itself. For an easterner, candidate areas might be the Grand Canyon National Park or Yellowstone National Park; for a westerner, the Maine coast or the Florida everglades. If the areas are indeed distant and quite costly to visit relative to home region alternatives, the probability of future use is likely to be small and dominated by exogenous random elements rather than explicit individual choice. With

probabilities of visitation parametric to the individual at the time of valuation, the expected utility model can be meaningfully applied.[11] Supposing the conventional additive utility structure over time, expected utility in future period t is

$$u_t = u_t\left[\sum_{t=1}^{3} \pi_{tk} \circ z_{tk}(x_{tk}, q_{tk})\right] \quad , \tag{2-35}$$

where $\sum_{t=1}^{3}$ denotes a lottery over the three described possibilities, k=1, 2, 3, and π_{tk} is the probability that in time period t recreational activity z_{tk} is chosen. For simplicity, suppose there is only one future period and that we can therefore suppress the notation t. Using the expected utility property,

$$\begin{aligned} u &= \sum_{k=1}^{3} \pi_k u[z_k(x_k, q_k)] \\ &= \sum_{k=1}^{3} \pi_k u_k(x_k, q_k) \quad , \end{aligned} \tag{2-36}$$

where $\sum_{k=1}^{3}$ denotes arithmetic summation. Thus, the case of parametric uncertainty leads to additive independence between activities and respective non-rival goods by a fairly direct route.

Proposition 1 is straightforwardly translated into the two valuation contexts detailed above. In the context of equivalent activites at different sites or in different regions, let $v_1(.)=a_i(.)$ and let the $v_2(.), \ldots, v_I(.)$ equal the respective I-1 elements of $a(x,\omega)$. Subcategory indexes conform to the site-or region-specific indexes of the market and

ition 1, then, non-rival goods used
erent regions are competitive in
me activity at the same site or
or complementary. To translate
n visitation, let K=3 , $v_i(.)=\pi_k u_k(.)$,
The subcategories index services specific
ivalent activities, non-rival goods
ions but may be either competitive,
thin the same region.

Table Page

stics of a given choice context can lead to
activities and categories of non-rival goods in the
additive separability between activities in the utility
independence in valuation. Quite the contrary. Given a
level of some non-rival good, an individual maintains
educed expenditure by shifting activity production
more productive activities and away from the relatively
thout direct complementary effects, activities
rival goods become relatively less productive. As individuals
y from these less productive activities, the value of associated
s declines. Thus, where non-rival goods are additively separable
onstrained expenditure minimization imposes strictly competitive
cross-qu ty valuation effects.

Propositions 1 and 2 provide the basis for a major empirical hypothesis to be tested in the experiment reported below. Nonindependence and the associated question of valuation sequence constitute one of the questions of contingent market structure. The other question concerns the process in

which value data (individual bids) are collected.

The literature reports a variety of ways to collect bids. Published studies have used devices ranging from a single direct question (e.g., Hammack and Brown, 1974), iterative bidding routines (e.g., Randall, Ives and Eastman, 1974), checklists (e.g., Schulze et al. 1981b) and payment cards (e.g. Mitchell and Carson). Considering this array of devices, we identify two important dimensions of the value data collection process: (1) the extent to which it provides the opportunity to iterate toward the maximum WTP (i.e., the points of indifference between paying WTP and obtaining the good, and doing neither); and (2) the amount of value-relevant or price-relevant information provided in the format. The payment card device (Mitchell and Carson) provides information on the cost per typical household of various public programs now in effect. A modified payment card developed by the authors provides additional information on typical annual expenditures for various market goods. Considering these two dimensions of the value data collection process, we propose the set of hypotheses 2, below.

The experiment reported below was designed to test the following hypotheses.

Hypothesis 1: The estimated value to Chicago residents of a specified atmospheric visibility program for the Grand Canyon is greater if measured independently than if measured last in a sequence which first considers programs for Chicago and all of the U.S. east of the Mississippi.

This hypothesis is derived from proposition 1.

Hypothesis 2: (a) The quality of value data is improved by the use of devices which permit more opportunities to iterate toward maximum WTP.

(b) The quality of value data is improved by the use of devices which provide a greater quantity of value-relevant (or price-relevant) information to assist the respondent in decision making.

We offer no hypothesis concerning the trade off between opportunity to iterate and the provision of value-relevant information.

To operationalize hypotheses 2(a) and (b), measures of value data quality must be defined. We propose the following measures:

(i) The larger the solid core of serviceable value data in a data set, the higher its quality. That is, the higher the frequency of protest bids and "too high" bids, the lower the data quality.

(ii) Since strategic and hypothetical influences both seem likely to increase the variance of a value data set, lower variance in individual bids is taken as an indicator of a better data set.

(iii) Increased regularity and predictability of a value data set is taken as an indicator of better quality. Thus, data sets which yield better bid equations are taken to be of higher qualtiy.

(iv) Since the evidence appears to tilt toward the conclusion that contingent markets underestimate sample mean values, any data set which exhibits unusually low mean bid (relative to the other data sets) is taken as of poor quality.

2.2.5 Structure of Contingent Valuation Instruments

As described above, both region-wide and special, geographically limited contingent valuation studies were carried out. The region-wide or general study instruments were of modular design to facilitate pre-testing and the coordination of the general and special studies. There are seven basic modules to the general study instrument.

Module 1: Area Context Module

The area over which visibility improvements were offered were required to be clearly comprehended by each individual. For the research to provide, among other things, guidance as to sub-regional allocation of resources for air quality improvement, it was important to collect WTP data for improvements in visibility (i) in the individual's home sub-region, and (ii) in the whole study region. Thus, for different purposes, the area context differed increasing the burden of communicating the area context to subjects.

Since the eastern region is larger than the customary territorial range of individuals, a map card as well as a portfolio of photographs were used to convey the size and diversity of the region over which visibility is valued.

Module 2: Visibility Module

The nature of alternative levels of visibility can best be communicated via color photographs. This required a set of scenes representative of the area over which visibility changes were to be valued. For each level of visibility a set of the same scenes, with only the visibility different, was used. Some purely factual verbal material (on cards, and delivered orally) was used to quantify the visual range represented in each photo set. In order for WTP for visibility improvements in both the home sub-region and the whole study region to be elicited separately, separate photo sets were needed to represent both the sub-region and the entire East.

Module 3: Activity Module

Since we conceptualize $V_i(w_{jk})$ as the value of visibility as an input in the production of z_{ijk}, it had to be hypothesized that $V_i = f(z_{ijk}...)$. To test that hypothesis, it was necessary to know the following:

1) the activities produced in the household,
2) the inputs, other than visibility, used in activity production,
3) the activity production technology used, and
4) whether visual air quality is the only air quality input used and, if not, whether visual air quality is used by the subject as an indicator of other aspects of air quality, For example, the individual may avoid strenuous outdoor sports on days of poor

> visibility, not because visibility per se is an important input, but because he treats poor visual air quality as an indicator of high pollutant concentrations which treatening respiratory stress.

The activity module was vital to the estimation of equation (3). In addition, the module served to sensitize the individual to the full variety of activities in which he might value visibility, thus eliminating possible sources of underestimation of V_i. A complete breakdown of all relevant activities would have been time-consuming and would have generated more data than could effectively be used in statistical analyses. Therefore, at the pre-test stage, considerable effort was allocated to devising and testing ways to more efficiently serve the basic purposes of this module.

Module 4: The Market Module

Contingent valuation established a hypothetical market and encouraged individuals to reveal their WTP by using that hypothetical market. Thus, the structure of hypothetical market was a major influence on the quality of WTP data. Major elements of this module described what was being purchased through the bid and the market rules regulating payment for and receipt of the good in question. To describe the good available for purchase, the general level of visibility as well as possible increments and decrements in visibility were portrayed in both photographs and narratives. Market rules provided assurance that the increment in visibility would be delivered if and only if the respondent was willing to pay. At the pre-test stage, alternative versions of the market module were developed and tested for their effect on bidding behavior.

Module 5: The WTP Data Collection Module

This module presented the fundamental WTP questions. In the Chicago research, questions were structured in several different ways. The first simply asked for a statement of WTP for some given improvement in visibility, the second used checklists of possible values from which a number representing maximum WTP was selected. The third used an iterative bidding format (e.g., Randall, et al, 1974). The fourth format presented information on relative tax prices of other public sector goods and then called for a statement of WTP for an increment in visibility. In this approach, the relative prices of other public programs served as reference points for the respondent.

Intensive pre-testing of WTP modules context was carried out. New WTP module designs were developed and tested. The most important modification to be introduced during the pre-test was the marginal bid question. Respondents bid first on local improvement, and then were asked how much they would add to their local bid to extend the improvement to the East and then to the entire U.S.

Module 6: Post-Bid Probing

With certain market rules and WTP formats, some individuals recorded a zero WTP which, in further questioning, turned out to be a protest against some aspect of the format rather than an accurate reflection of the value of the good offered. Probing of zero WTP's was, therefore, a routine element of the data collection schedule.

Even with protest bids eliminated, it has recently been shown that WTP data generated by individuals who are in some way uneasy with the market rules and WTP format exert a highly significant downward influence on mean WTP

(Brookshire, Ransdall, and Stoll). Thus, it was necessary to provide opportunities for subject to confidentially evaluate the WTP instrument for credibility/plausibility and their own responses as valid WTP indicators. These evaluations were taken into account in developing the CV instrument used in the six eastern cities.

Module 7: Socio-Demographic Data

This module collected an array of socio-demographic data used to estimate equation (3). It has been argued (Second Quarterly Progress Report, Exhibit C) that full income concepts are highly relevant to the processes through which individuals demand and hence value, visibility. Thus, questions have been included in the CV instrument to capture the concept of full income and collect the appropriate data.

Implementation of Contingent Valuation

Following completion of those special studies which were designed to serve as pre-tests and pilot studies for the general study, the general study instrument was finalized. A region-wide data set was assembled during the winter of 1981 and analysis was completed during by January 1983.

Special studies address key issues in the design of effective contingent valuation devices. Two objectives were served: (1) the selection of thoroughly tested contingent valuation devices for use in the general study; and (2) the generation of experimental data sets which permitted formal comparison of the effectiveness of contingent valuation devices under consideration for use in the general study and additional devices used in previous research. Thus, this phase of the research design was intended to permit advances in the implementation of contingent valuation.

Formal experiments compared alternative systems of disincentives for strategic and hypothetical biases, and alternatives WTP data collection formats. The latter effort tested the four basic formats identified above, a fifth format combining formats (3) and (4), and two experimental formats newly devised during the current research. The two new formats were, resepectively, an "interative bidding with budget breakdown and reiteration" format, and group decision format utilizing linked computer consoles.

This work permitted (1) the first rigorous test of hypotheses about the efficieincy of a wide variety of WTP formats, (2) the selection of one, well-validated, WTP format for use in the general study, and (3) by selecting for study some visibility values in specific markets, also examined via secondary data analyses, the completion of test for corroboration and replication of CV results with behavioral data.

In addition to formal experiments, a series of informal studies using open-ended questioning, content analysis, and similar techniques were used to explore a series of important issues in instrument design for the general study. The purpose of these informal studies was to gain an understanding of citizen's perceptions in order to permit more effective communication with the general study subjects, and to develop more effective ways of obtaining important and/or sensitive information. Informal studies explored:

___how citizens conceptualize visibility, and the effectiveness of color photographs in communicating visibility to them.

___whether visibility is best presented in typical or in frequency terms.

___the activities Z_{ijk}, for which visibility is an input; in what sense is it an input, i.e., in what ways does poor visibility hinder activity production; is it a major or minor input; is visibility used by citizens as an indicator of other air-pollution-related problems, e.g., respiratory stress; in order to reduce data collection time and data overload, can meaningful categories of activities be developed?

___are there effective ways to gather information about activity production technologies (e.g., acquired outdoor skills) and complementary inputs (especially, specialized consumer durables), again without data overload.

___particular versions of the wording of modules 4 and 5 can be examined for effectiveness of communication and comprehension.

___can the notion of full income (which includes income, the marginal wage rate, and wealth] be implemented without an unacceptable number of refusals to answer particular questions?

2.2.6 The Chicago Contingent Valuation Experiment

2.2.6.1 Basic Contingent Valuation Structure

Following a small-scale pretest, a major pilot study was conducted to generate contingent valuation estimates of the value of atmospheric visibility. This pilot study was conducted by personal interview in the city of Chicago and suburban Cook and DuPage counties. The basic instrument contained sections for collection of the following data:

--Indicators of attitudes toward environmental quality.

--Activities of respondent (categorized as indoor-outdoor, strenuous or otherwise, etc.); identification of activities for which the respondent had invested in acquiring specialized skills or knowledge; identification of activities which are avoided for health, etc. reasons; and identification of activities the respondent was more likely to do on days when visibility was unusually good, and those he was less likely to do on poor visibility days.

--Ownership of or access to, equipment which could be used in activities which also use visibility (e.g., cameras with telescopic lens, binoculars, etc.).

--Contingent valuation modules that describe three alternative levels of visibility in the immediate Chicago region; one alternative level in the much broader east-of-the-Mississippi region; and one alternative level at the Grand Canyon. Verbal descriptions and color photographs were provided. Visual range in miles were stated and contingent market rules were defined. Respondents were given the opportunity to re-examine all 5 bids and adjust any or all of them. Protesters were identified--for example, respondents who objected to citizens bearing the costs of environmental clean-up. Six interchangable CV modules were used, each differeing only in the process by which bids were collected.

--Time horizon, with respect to expected length of residence near Chicago or east-of-the-Mississippi.

--Homeowner or renter status, estimated rental value of home, and rental income from other residential real estate owned.

--Quality of view from the place of residence.

--Socio demographic information about respondent and other household members, including income, wealth, average and marginal wage, and income expectations, as well as age, sex, education, race, ethnicity, etc.

A randomized cluster sampling design was developed, with a cluster size of six and specific instructions that each CV module be used once and once only within a cluster. Sixty starting locations were randomly selected using a computer routine which (after eliminating high density neighborhoods where interviewers would have trouble gaining access to apartments) gave every citizen in the region an equal chance of having his residence selected as a starting location. Thus, the target sample size was a maximum of 60 (and a minimum of 50) interviews with each CV module, for a total of at least 300 and no more than 360 interviewers.

2.2.6.2 Alternative Formats

The six contingent valuation formats used varied only in the process via which WTP bids were collected. They were:

A_1 directly asked respondents to report their maximum WTP, as Hammack and Brown (1974) had done in a mail survey.

A_2 stated an amount, invited acceptance or rejection of the program at that price, and then asked maximum WTP. This format duplicated the procedure used by Bishop and Herberlein (1979) to collect contingent WTP.

A_3 was an iterative bidding routine similar to those previously used by Randall, Ives and Eastman (1974) and Brookshire, Randall and Stoll (1980), among others.

B allowed respondents to indicate their maximum WTP by checking the appropriate number on a checklist of possible numbers. This format had been used by Schulze et al (1981b).

C_1 provided a payment card, as developed and used by Mitchell and Carson.

C_2 expanded the payment card concept to include typical annual household expenditures (by income group) on several categories of goods purchased in the private sector, as well as typical annual household costs of public programs.

As one progresses from A_1 to A_3, there is successively more opportunity to iterate toward the point of indifference between (1) paying the amount stated and taking the good and (2) paying nothing and foregoing the good. Formats C_1 and C_2 provide information on the current levels of household expenditure on other goods and public programs; C_2 provides a greater array of such information than C_1. Format B has been promoted by Schulze et al (1981b) as speeding-up the data collection process relative to, say, A_3 and eliminating the possibility of starting point bias.

2.2.6.3 Results

A data tape containing results of 273 completed interviews was used. While the target was 300 to 360 interviews, a few aborted interviews had to be discarded and a few stragglers had not been completed, coded and added to the data set. All analyses reported below are based on this set of 273 observations.

Let us look first at the effect of value data collection format. Hypothesis 2(a) suggests that formats A_3, A_2 and A_1 are expected to generate value data of highest, medium and lowest quality, respectively. hypothesis 2(b) suggests that formats C_2, C_1 and B are expected to generate data of highest, medium and lowest quality, respectively. There is no a priori hypothesis about relative value data quality across the two sets of formats.

All three A formats and format B generated noticeably more protest bids than the C formats (Ta.2-1). The differences in generation of high bids were not so noticeable. However, the C formats clearly generated a larger solid core of serviceable value data than the A and B formats. Examining this solid core (the 4 rightmost columns of Ta.2-1), we notice that formats A_2 and B produced notably lower sample mean bids, and C_2 produced notably higher sample mean bids than the others. Within the solid core, there is little to be observed with respect to dispersion of bids. If one considers for example the mean bid relative to its standard error, the formats do not perform very differently.

Since the format subsamples are small (fewer than 50 bids in every case, and as few as 31 solid core bids in the case of A_3), it is important to control for differences in household characteristics across the sub-samples OLS regression analysis was used for this purpose.[12] Two regression specifications suggest themselves for estimation: the familiar linear-in-levels specification (2-37)and an alternative specification (13) developed below.

The linear-in-levels specification posits

$$WTP(q_j^{\circ}, q_j')_k = b_o + \Sigma b_i Z_{ik} + e \quad , \tag{2-37}$$

where k=1, ..., K refers to individual households; Z_1 is a vector of descriptors of the household's endowments, consumption technology, etc.; b_l are estimated parameters; and e is the error term.

Since one would suspect that (2-27) is likely to be non-linear, an alternative non-linear specification was developed. Rearranging (2-27) and entering the vector of human capital endowments α, we obtain

$$(m + CS)/m = 3(p, q', \alpha, u)/e(p, q^{\circ}, \alpha, u).$$

If u can be approximated by a homothetic direct utility function, the above

TABLE 2-1

Value Data, Atmospheric Visibility, Chicago 1981, by Format.

Format	Sample Size (n)	Zero bids All (% of n)	Zero bids Protest (% of n)	High Bids[a] (% of n)	Mean Annual Willingness to Pay per Household (Stand. Error of Mean) Full Sample WTP9[c]	WTP10[d]	WTP11[e]	n	Solid Core[b] WTP9[c]	WTP 10[d]	WTP11
A_1	47	15	15	21	278 (191)	300 (116)	380 (145)	37	250 (51)	250 (50)	236 (50)
A_2	45	24	18	11	140 (26)	136 (22)	157 (24)	35	156 (30)	147 (22)	171 (24)
A_3	45	22	18	18	312 (133)	299 (132)	329 (133)	31	222 (37)	210 (38)	240 (39)
B	46	22	15	24	98 (21)	88 (18)	150 (34)	36	121 (25)	109 (22)	152 (29)
C_1	45	8	2	13	296 (66)	250 (61)	322 (74)	42	210 (44)	186 (35)	234 (53)
C_2	45	4	0	16	425 (121)	446 (123)	560 (145)	42	283 (57)	324 (72)	456 (115)
TOTAL	273	17	11	17	258 (36)	253 (38)	316 (44)	221	227 (20)	218 (20)	271 (28)

[a] Definded as any bid amounting, on an annual basis; to more than 10 percent of SOL.

[b] High bids were reduced to 10 percent of SOL. In addition, 12 erratic bidders were removed from the sample.

[c] WTP to avoid a reduction in visibility from 9 miles to 4 miles.

[d] WTP to get an increment in visibility from 9 miles to 16 miles.

[e] WTP to get an increment in visibility from 9 miles to 30 miles.

equation can be approximated by a normalized version ε,

$$(2\text{-}37) \qquad (m + CS)/m = \varepsilon(p, q', \alpha, \ell | q^{\circ}) \quad ,$$

which describes the proportional reduction in minimum expenditures due to the change in q as a function of prices, subsequent q', household characteristics and an error term ℓ --all conditional on the reference level of q, q°. If (2-37) can be further approximated by a multiplicative form, the following log linear form can be specified:

$$(2\text{-}38) \qquad \ln(1 + CS/m)_k = b_o \ \pi Z_i^{b_i} \exp(\Sigma b_j d_j) e \quad ,$$

where d_j are dummy variables.

Results Of estimating models (2-36) and (2-38) for WTP11 are presented (Ta.2-2 and 2-3, respectively).

Household standard of living, respondent's age, a grade 12 or lower education, and the environmental index clearly influenced WTP11 in the expected directions (Ta.2-2). Using format A3 as a basis for comparison, only format C_2 appeared to generate significantly different solid core bids. Turning to the non-linear specification (Ta.2-3), we find the numbers of adults in the household and the wage rate exerting significant influence, along with several of the same variables which were influential in (2-36). However, no format generated a sample of bids significantly different from A_3. Our conclusion is that, for the most part, the choice of format seems to exert statistically insignificant influence on the solid core bids.[13]

In summary, it is clear that formats C_1 and C_2 elicited fewer protest bids than the other formats. Beyond that, little else is yet clear with respect to hypotheses 2(a) and (b) and the performance of the alternative formats.

TABLE 2-2

Estimated Bid Equation, WTP11, Using Specification (11).

Dependent Variable: WTP11[a]

DFE 180
F RATIO 3.04
PROS>F 0.0007
R-SQUARE 0.1684

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	172.4	112.7	1.52	0.127
SOL	1	3.9	2.4	1.58	0.115
RYOUNG	1	-90.1	63.9	-1.41	0.160
RSENIOR	1	-90.0	79.2	-1.13	0.257
QHIGHS	1	-82.2	59.9	-1.37	0.171
QGRAD	1	-40.6	81.1	-0.50	0.616
ENVIR	1	7.9	3.0	2.58	0.010
CITPAY	1	74.4	55.1	1.34	0.178
A_1	1	11.0	96.3	0.11	0.908
A_2	1	-52.2	91.8	-0.56	0.570
B	1	-51.0	97.3	-0.52	0.601
C_1	1	4.4	91.6	0.04	0.961
C_2	1	170.0	91.2	1.86	0.064

Independent Variables

SOL = Annual household income divided by the Lazear - Michael (1980) index of standard of living.

RYOUTH = 1 if age of respondent < 35 years.
= 0 otherwise.

RSENIOR = 1 if age of respondent $\geq$ year.
= 0 otherwise.

QHIGHS = 1 if highest level of education of respondent, head, or spouse of head of household is a high school diploma or less.
= 0 otherwise.

QGRAD = 1 if highest level of education of respondent, head, or spouse of head of household is one or more years beyond a bachelor's degree.
= 0 otherwise.

ENVIR = an environmental attitude index estimated for each individual on the basis of observations obtained in section 1 of the interview.

CITPAY = 1 if respondent stated that citizens should pay the cost of environmental improvement.
= 0 otherwise.

TABLE 2-2. Continued

A_1, A_2
B, C_1, C_2 = 1 if an observation from a given format. = 0 otherwise.

[a]WTP11 is willingness to pay for an improvement in visibility from 9 to 30 miles. Sample includes solid core responses only.

TABLE 2-3

Estimated Bid Equation, WTP11, Using Specification (13).

Dependent Variable: Percent*

DFE 159

F RATIO 2.53
PROD F 0.0014
R-SQUARE 0.2126

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB T
INTERCEPT	1	4.5771	0.00594	770.10	0.001
LNWAGE	1	0.0031215	0.00166	1.87	0.063
RYOUNG	1	0.0018667	0.00251	0.74	0.459
RSENIOR	1	0.0074137	0.00354	2.09	0.037
QHIGHS	1	-0.003111	0.00239	-1.30	0.195
QGRAD	1	0.0012065	0.00310	0.38	0.698
ENVIR	1	-0.0002132	0.000129	-1.64	0.101
CITPAY	1	-0.0003975	0.00220	-0.40	0.684
HA_2	1	0.0105	0.00305	3.45	0.001
HA_3	1	0.0103	0.00369	2.81	0.005
HC_1	1	0.0076425	0.00325	2.42	0.016
HC_2	1	-0.001909	0.0029	-0.65	0.516
HC_3	1	0.0625697	0.00330	0.77	0.437
A_1	1	-0.0009201	0.00386	-0.23	0.812
A_2	1	0.0035101	0.0037	0.93	0.349
B_2	1	0.0037209	0.00395	0.94	0.348
C_1	1	-0.001814	0.00371	-0.48	0.626
C_2	1	0.00065131	0.00364	0.17	0.858

LNWAGE = Natural log of the respondent's marginal wage.

HA_2 = 1 if household includes two members whose age is greater than or equal to 18 years.
= 0 otherwise.

HA_3 = 1 if household includes three or more members whose age is greater than or equal to 18 years.
= 0 otherwise.

HC_1 = 1 if the household includes one member of less than 18 years of age.
= 0 otherwise.

HC_2, HC_3 are similarly defined for households with 2, and 3 or more members less than 18 years of age.

See Table 2 for definitions of other included variables.

*Percent is the natural lof of $(m - \frac{WTP11}{m})(100)$.

Now we consider the valuation sequence. Question 10 considered an increment in Chicago-area visibility from a typical level of 9 miles to 18 miles. Q 12 considered a similar visibility improvement over the whole east-of-the-Mississippi region. Q 13 considered the visibility program offered in Q 12 plus a program to prevent a threatened visibility decline at the Grand Canyon. In the previous year, the authors had collected in Chicago 128 bids to prevent the decline in Grand Canyon visibility,[14] using formats A_3 and B. Adjusting for one-year's inflation, these two data sets permit a test of Hypothesis 1. Thus, we hypothesize that WTP to prevent the visibility decline at the Grand Canyon when measured independently is greater than when measured third in a sequence of three visibility programs.

Given a Chicago-eastern region-Grand Canyon valuation sequence, the Grand Canyon program was valued by Chicago residents at a little more than 10 percent of the value of a Chicago program (Ta.2-4). More interesting, a direct

comparison of the independently measured value of the Grand Canyon program (GCBid, Ta.2-5) with the value of the same program considered third in a three-program sequence (WTP13 - WTP12, Ta.2-5) shows the mean value of the former was more than five times the mean value of the latter. A linear regression analysis (Ta.2-6) shows that GCBid and WTP13 - WTP12 are different, at a very high level of significance. Thus, the null version of Hypothesis 1 is emphatically rejected.

2.2.7 Conclusion

Our experiment permits a clear conclusion with respect to Hypothesis 1: the null version is rejected. In the light of Propositions 1 and 2, this indicates that to the individual, visibility programs in Chicago, the east-of-the-Mississippi region and the Grand Canyon are substitutes: not perfect substitutes, but substitutes nevertheless.

If the real world of policy is characterized by the simultaneous augmentation of several collective goods in one or more policy packages or programs, our conceptual Propositions 1 and 2 and our empirical test of Hypothesis 1 suggest the following conjecture. If these several collective goods are each valued independently and the independent values then summed to determine the value of the program, the value of the program is inevitably overestimated (except in the special case where the program elements are strong complements). This conjecture would seem to apply when $q = (q_i, q_j, q_k)$ is defined so that i, j and k are regions (as in our experiment) or goods with different characteristics, e.g., visibility, health-related air quality, and water quality. All that is needed is substitute relationships among the elements of the q vector.

We have much less to say about the effect of value data collection format. It is clear that the payment cards were helpful in reducing the incidence of protest bids. Eyeball evaluation of mean bids suggests that formats A_2 and B

TABLE 2-4

Incremental Mean Value (and Standard Error) of Regional and Canyon Visibility Programs

Format	Sample Size[a] (a)	WTP10 ($/year)	Regional Program; WTP12 - WTP10 ($/year)	Grand Canyon Program; WTP13 - WTP12 ($/year)
	29	382 (183)	161 (72)	30 (21)
A_2	31	139 (23)	14 (6)	9 (6)
A_3	27	375 (217)	29 (12)	12 (6)
B	32	103 (24)	26 (8)	20 (11)
C_1	29	251 (86)	21 (9)	39 (28)
	26	608 (206)	354 (181)	83 (76)
Total	174	298 (58)	95 (31)	31 (13)

[a]Protest bids eliminated; erratic bids (e.g., those which bid more for a less-preferred program) eliminated; "high" bids neither eliminated nor reduced.

TABLE 2-5

The Value of a Grand Canyon Program to Chicago Residents.

Format[a]	GCBid 1980[b] (adjusted)			WTP13 - WTP12 1981[c]		
	n	Mean	SE	n	Mean	SE
A_3	57	69.02	13.84	27	12.00	5.58
B	73	105.64	24.91	32	19.88	10.892
A_3 and B pooled	130	89.58	15.28	59	16.27	8.942

[a] Since the GCBid 1980 survey used only the A_3 and R formats, only the A_3 and B format results for WTP13 - WTP12 are shown.

[b] GCBid 1980 is an independent valuation.

[c] WTP13 - WTP12 is a valuation of the same program, obtained third in a three-program valuation sequence.

TABLE 2-6

Willingness to Pay for the Grand Canyon Program: Independent versus Sequential Programs.

Dependent variable: Annual WTP to avoid visibility decline at Grand Canyon		DFE: 152		F RATIO 4.41 PROB>F 0.0002 R-SQUARE 0.1689
VARIABLE[a]	D F	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO	PROB>|T|
INTERCEPT	1	26.8	27.5	0.97	0.331
SOL	1	1.3	0.9	1.43	0.152
RYONG	1	-3.5	21.8	-0.16	0.871
RSENIOR	1	-65.8	31.5	-2.08	0.038
RHIGH	1	52.5	24.0	2.18	0.030
RGRAD	1	63.6	36.2	1.75	0.081
Z1	1	-74.7	23.5	-3.17	0.001
CITPAY	1	54.0	19.2	2.80	0.005

[a]Variables are defined as before, except for Z1, which is defined as
Z1 = 1 if WTP13 - WTP12 (i.e., third in a three-program valuation sequence)
= 0 if GCBid 1980 (i.e., independent valuation)

seem to generate lower mean bids in the solid core, and C_2 seems to generate higher mean bids, than the other formats.

More generally, we believe the effect of data collection format is a useful subject for further study. We suspect that, within the set of well-designed contingent markets, format makes some limited difference. However, we would be hesitant to casually apply some lable (such as "information bias") to this effect. In real-world and actual-experiment markets, market structure has some influence, and logic suggests that it should. That same kind of logic should be applied to contingent markets.

Contingent markets generate a solid core of serviceable value data, but a persistent fringe of protest bids and suspiciously high bids require and have received close examination. We perceive substantial convergence between the kinds of results we obtained in this and previous studies and the results of, e.g., Smith (1980).

The research agenda has shifted from "contingent valuation (CV) must be assumed useless because it is not incentive-compatible" to "CV must have some merit <u>because</u> its results are consistent with those of hedonic methods" [15] (Brookshire, <u>et al</u>., 1982). On the immediate horizon, in recent CV and experimental work (Smith, 1980) we see some indication that CV may have merit simply because many people really do try to tell the truth much of the time. The stage now appears set for a further shift in the research agenda toward painstaking study of the effects of contingent market structure on the quality of value data generated. In this process, we might expect a further convergence of survey and experimental methods.

We can expect however that there are limits to truth-telling. While income tax liability is self-reported, the IRS finds the need to employ auditors, inspectors and systematic reporting procedures. The possibility must be entertained

that if CV were widely and routinely used to gather data which directly influenced many public programs, and "everyone" knew it, more people would invest in strategic efforts to influence its results.

FOOTNOTES

1. This seems to be a typical finding when cross-sectional data are used. For example, changes in the aggregate level of consumer confidence have predicted the onset of the last six recessions and the onset of each subsequent recovery. However, individual consumption and saving decisions are not predictable on the basis of individual consumer confidence (Katona, 1980).
2. We find much of the discussion of "biases" in contingent valuation imprecise and not especially perceptive. It seems to us that a bias is a systematic influence, predictable in its occurrence and the direction of its impact on results. Many of the "biases" identified in the lieterature cited as merely possible sources of (a priori undetermined) observation error.
3. We wish they had used the term, conjecture.
4. We believe their experiment was subject to certain influences which would lead to overestimating the difference between contingent WTP and true value. Nevertheless, we believe these influences were insufficient to account for all of the observed differences between contingent WTP and actual WTS. Thus, it is our

position that Bishop and Heberlein's result may overstate the difference between contingent WTP and true value, but is unlikely to have misidentified its sign.

5. Why underestimation? We do not know for sure, but we conjecture that contingent markets may take basically unprepared subjects by surprise. While their instinct in such circumstances is probably to tell the truth, their unpreparedness and inexperience with such markets leads to a cautious and conservative response: in WTP markets, to "sit pat" (i.e. bid zero) or to bid conservatively. This conjecture is also consistent with the observed high bidding behavior of many respondents in contingent WTS markets. In that circumstance, the cautious response is to refuse to sell or to announce a high selling price.

Since Bishop and Heberlein's (1979) experimental WTS market was highly unusual and new to its participants, we suspect that it was subject to the influence conjectured above. If so, that would account for some portion of the observed difference between experimental WTS and contingent WTP.

6. Small and Rosen (1981) address the difficulty introduced by lack of smoothness in the expenditure function when $x_i(p, q, \pi, a, u)$ approaches zero.

7. Substitute relationships are more likely to occur than complementary relationships, although both kinds of relationships are possible.

8. In a working paper, the authors show that these restrictions are not peculiar to contingent valuation but apply also to those procedures which seek to infer the value of q_i by analyzing the demand for x_i (see Freeman, 1979).

9. Proof of Proposition 1 follows from the comparative static properties of the additively separable utility function. A full proof is given in Hoehn.

10. In a similar context Domenich and McFadden characterize additive separability as a "good general working hypothesis" (p.40).

11. The context described corresponds fairly closely to Malinvaud's case of individual risks. Graham argues that in this case option price is a lower bound on the correct BC measure of value.

12. Subsequent analyses will use methods more appropriate to the distribution of WTP observations. Some analysts have successfully used tobit (e.g., Adams et al., 1980). We propose to use censored sample correction methods (see Gronau, 1974; Heckman, 1976 and 1979) to more closely analyze protest bids, "high" bids and "solid core" bids.

13. It happens that the subsample which used format C_2 had (by pure chance, so far as we know) mean household income some $5,000 higher than the whole sample. One hypothesis for further investigation is that the non-linear specification (13) better accounted for a possible non-linear relationship between income and bid.

14. This survey was a contribution to work, reported by Schulze et al (1981b).

13. This position is logically supportable only if we accept the (untestable) premise that hedonic methods reveal true value.

2.3 ALTERNATIVE ECONOMETRIC SPECIFICATIONS

2.3.1 Overview of Section 2.3

Section 2.3 reports the results of early CV experiments in Chicago on Grand Canyon National Park. The main purpose of these experiments was to investigate the solution to an important econometric problem--the presence of a substantial number of zero valuations of visibility improvements in the DV data. Ordinary least squares regression estimates, frequently employed in econometric analysis, can bias the results when a limiting value (zero in this case) occurs in the data set. Accordingly, tobit and logit specifications were investigated.

The conclusion was that the empirical results were consistent with conceptual reasons for employing tobit analysis. Tobit analysis is designed for use in models in which the dependent variable takes on a limiting value (zero) or a non-limiting value of some specific (positive) amount.

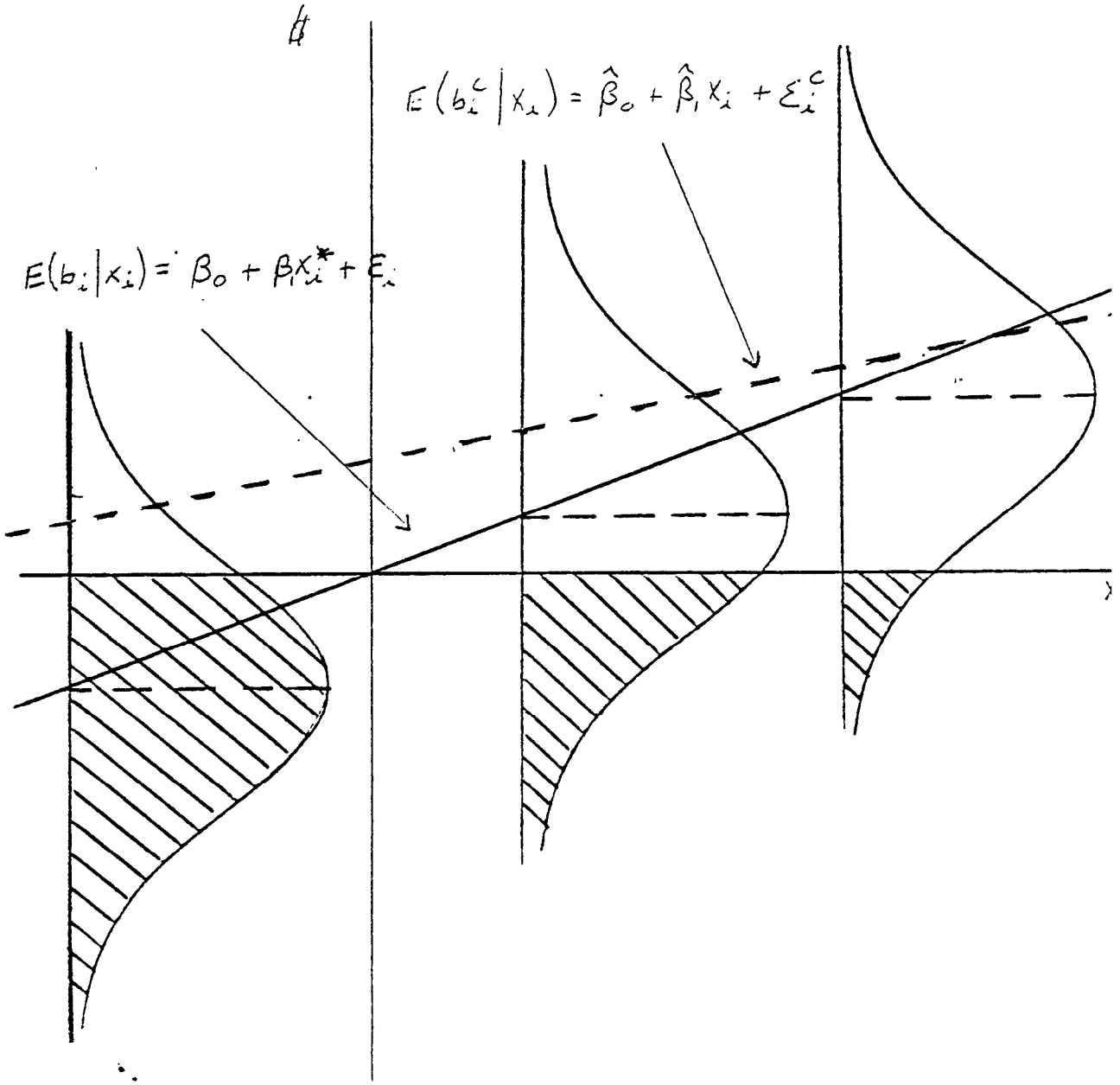
2.3.2 Tobit Estimation

2.3.2.1 Estimation When the Dependent Variable is Truncated

In the bidding game, an individual i's bid b_i, is elicited on the basis of some increment or decrement in visibility. Analytically then, the bid function becomes $b_i = \beta_o + \beta_1 x_i^* + \varepsilon_i$, where x_i is a vector of individual attributes including the represented level of visibility, and ε_i is a normally distributed random error term. As the increment of visibility x_{ij}, approaches zero, the distribution of the error term causes more and more of the b_i to fall on the negative side of the abscissa. With bids limited to the positive quadrant (no one pays a negative amount to get more visibility), the error term causes an accumulation of zero bids. The effect of such a limit causes the distribution to be truncated at zero. With truncation, ordinary least squares (OLS) estimators result in the regression line $E(b_i^c \mid x_i)$, the dotted line in Fig. 2-1. OLS tends to bias the estimation of β_o and β_1 and, in the illustrated case, cause $\hat{\beta}_o$ to be greater than β_o and $\hat{\beta}_1$ to be less than β_1. Because of OLS bias the statistical significance of $\hat{\beta}$ is reduced and the effect of an increase or decrease in the variable x_{ij} is underestimated. Truncation may therefore contribute to the usual problem of insignificant income effects or the underestimation of the rate at which bids increase with increments in visibility.

FIGURE 2-1

The Tobit Model with Lower Limit L = 0



To deal with the problem of truncation, tobit analysis was used. Tobit analysis uses the distribution of the error tern, e_i , and the number of zero bids as information in the estimation process. Depending upon the seriousness of the truncation problem, tobit analysis will improve estimates of the coefficients B_0 and B_1 in the bid function.

2.3.2.2 Tobit Analysis of Three National Parkland Study Experiments

This section presents results of the National Parkland Study's (NPS) valuation of visibility. Previous analysis of the Chicago resident data were discouraging in that selected independent variables did not show a significant and systematic effect on individual bids. Bid functions estimated using ordinary least squares fit the Chicago data poorly. Because the independent variables of interest were consistently shown to be insignificantly related to the bids, tests of hypotheses regarding instrument design were impeded.

Results of a review of the concepts suggested tobit analysis as a potentially superior means of explicitly accounting for zero valuations. Reported below are the output of a tobit analysis.

The collaborative effort with NPS offered an opportunity for a contingent valuation experiment. Three different questionnaires were used: The AAA check-list, the AAA bidding game, and the CCC bidding game. The three CV formats were combined with a photographic display. The photographs represented five different levels of visibility, ranging from very poor at level A through intermediate levels B, C, and D to very good visibility at level E. Each of the three CV formats described level C as the current level of visibility. The CCC format elicited valuations directly from level C. Five CCC bids were elicited; (1) to improve Grand Canyon visibility from the current level C to level E, (2) to prevent a decline in Grand Canyon visibility from level C to level B, (3) to prevent a

decline in Grand Canyon visibility from level C to level A, to improve regional visibility from level C to level E, and (5) to prevent a decline in regional visibility from level C to level A. The AAA formats described a decline in visibility to level C and elicited all bids as bids for improvements from level A. For visibility at the Grand Canyon, the AAA formats elicited three bids: bids for the improvements from A to b, A to C, and A to E. For regional visibility, the AAA format elicited bids for improvements from A to C and from A to E.

The bid function specified for the tobit analysis differed little from that used earlier in the ordinary least squares estimates. The variables in the bid function were:

ED - The number of years of schooling completed by the respondent.

A2534 - A zero/one dummy variable. Equals one if the respondent's age is from 25 to 34 years and zero otherwise.

A3544 - A zero/one dummy variable. Equals one if the respondent's age is from 35 to 44 years and zero otherwise.

A4554 - A zero/one dummy variable. Equals one if the respondent's age is from 45 to 54 years and zero otherwise.

A55+ - A zero/one dummy variable. Equals one if the respondent's age is 55 or more and zero otherwise.

INC - Income in thousands of dollars.

USTGC - A zero/one dummy variable to indicate whether or not the individual has plans to visit the Grand Canyon, Equals one if yes, has plans, and zero otherwise,

PSTGC - A zero/one dummy variable to indicate whether or not the individual has visited the Grand Canyon. Equals one if yes and zero otherwise.

SEX - A zero/one dummy variable to indicate whether or not the sex of an individual. Equals one if male and zero otherwise.

PRIM - A zero/one dummy variable to indicate whether or not the respondent is the primary income earner in household. Equals one if yes and zero otherwise.

CITPAY - A zero/one dummy variable. Equals one if respondent believes that all citizens of U.S. should pay the cost of visibility impairment and zero otherwise.

USTPAY - A zero/one dummy variable. Equals one if respondent believes that visitors to National Parks should pay the cost of preventing visibility impairment and zero otherwise.

POLPAY - A zero/one dummy variable. Equals one if respondent believes that polluters should pay the cost preventing visibility impairment. Equals one if yes and zero otherwise.

A priori notions regarding the sign attached to variables in the estimated bid equation were much the same as with the OLS test. ED, INC, and USTGC were expected to affect valuations positively. The effect of respondents' age, given the N.P.S. results, was expected to be negative. Age was entered as a dummy variable in order to test for non-linear effects of increasing years and to more accurately represent the actual responses elicited from respondents. No a priori notions were held regarding the estimated signs of PSTGC, SEX, PRIM, CITPAY, USTPAY, and POLPAY.

Dependent variables in the estimated bid functions are the five valuations elicited in each question. A valuation is identified by a four letter code (see Ta.2-7, 2-2 and 2-9). The first two letters indicate the area or region that could be affected by the bid; GC__indicates the Grand Canyon and RE__ indicates the regional parks as a whole. The second two letters indicate the increment in visibility for which a bid was elicited. For instance, __AB indicates a program that would shift visibility from level A to level B.

Bid functions estimated on the three sets of data are presented in Tables 1, 2, and 3, Examining the results overall, note first that the number of observations was similar in each case. Second, the number of zero bids tends to decline as the increment in visibility is increased. This tendency of zero bids is consistent with the conceptual framework justifying a tobit analysis. Third, average bids ($E(Y\ x=\overline{X})$) tend to increase as the increment in visibility increases. This trend in

TABLE 2-7

AAA Checklist Results
(|t| values in parentheses)

Dependent Variable	GCAB	GCAC	GCAE	REAC	REAE
# of OBS	57	57	57	57	57
# of Zero Bids	18	16	11	15	11
ED	-00962 (.87)	-.0518 (.46)	-.0159 (.14)	.0111 (.10)	.1593 (1.39)
A2534	-.4801 (.94)	-.0738 (.15)	.1346 (.27)	.0854 (.17)	-.3505 (.70)
A3544	-.3346 (.66)	.1243 (.25)	.6961 (1.40)	.1021 (.21)	.5452 (1.10)
A4554	-1.402 (2.33)	-.5974 (1.04)	-.2721 (.47)	-.5737 (1.00)	-.3461 (.60)
A55+	-1.174 (2.30)	-.8504 (1.67)	-.3812 (.79)	-.7858 (1.58)	-.5949 (1.21)
INC	-.0014 (.10)	.0091 (.62)	.0086 (.61)	.0003 (.02)	.0001 (.01)
USTGC	-.0164 (.04)	.0160 (.04)	-.0641 (.18)	-.1483 (.41)	-.2761 (.78)
PSTGC	-.4327 (1.27)	-.3482 (1.02)	-.0084 (.03)	-.1218 (.36)	.4593 (1.37)
SEX	-.0962 (.24)	-.0995 (.24)	-.0220 (.05)	-.0583 (.14)	-1.640 (.40)
PRIM	.4740 (1.16)	.0983 (.24)	-.4299 (1.05)	-.0065 (.02)	-.3068 (.74)
CITPAY	.8418 (2.57)	1.059 (3.16)	1.126 (3.38)	.9943 (3.00)	1.228 (3.61)
USTPAY	.4157 (.86)	.6953 (1.52)	.9206 (1.99)	.8151 (1.77)	.8951 (1.94)
POLPAY	-.1670 (.47)	-.2971 (.84)	-.3720 (1.07)	-.3801 (1.08)	-.2712 (.78)
Constant	2.142 (1.31)	.8227 (.48)	.1212 (.07)	.2006 (.12)	-2.095 (1.19)
$1/\sigma$	.1602	.0837	0.569	.1262	.0630
$P_v(Y>0 \mid x=\bar{x})$	.603	.579	.644	.628	.649
$E(Y \mid x=\bar{x})$	3.39	6.05	10.72	4.62	9.84
R^Z	.376	.365	.400	.350	.454

TABLE 2-8

AAA Bidding Game Results
(|t| values in parentheses)

Dependent Variable	GCAB	GCAC	GCAE	REAC	REAE
# of OBS	50	50	50	50	50
# of Zero Bids	7	6	6	4	3
ED	-.0069 (.09)	-.0880 (1.10)	-.033- (.42)	-.1334 (1.67)	-.1128 (1.43)
A2534	-.4590 (.84)	-.7812 (1.42)	-.6631 (1.23)	-.7476 (1.37)	-.9802 (1.83)
A3544	-.1252 (.21)	-.3248 (.54)	-.1437 (.24)	-.4026 (.67)	-.5212 (.88)
A4554	-.4361 (.63)	-.4460 (.65)	-.3113 (.46)	-.5435 (.80)	-.7563 (1.13)
A55+	-.3076 (.57)	-.4968 (.92)	-.4270 (.80)	-.3441 (.64)	-.5962 (1.13)
INC	-.0042 (.31)	-.0020 (.14)	-.0009 (.07)	-.0039 (.29)	-.0000 (.00)
USTGC	.3171 (.91)	.5507 (1.58)	.5613 (1.61)	.4882 (1.42)	.4256 (1.24)
PSTGC	.5567 (1.37)	.3284 (.79)	.2877 (.69)	.3650 (.89)	.3563 (.87)
SEX	.0184 (.04)	-.1421 (.34)	-.0739 (.18)	-.1465 (.35)	-.1596 (.39)
PRIM	-.1231 (.28)	.5664 (1.28)	.4318 (.98)	.6525 (1.50)	.5848 (1.35)
CITPAY	.8005 (2.31)	.7876 (2.29)	.7452 (2.17)	.7649 (2.24)	.6896 (2.03)
USTPAY	-.2291 (.48)	-.3464 (.74)	-.3689 (.80)	-.3836 (.82)	-.3351 (.72)
POLPAY	.5675 (1.41)	.8425 (2.07)	1.044 (2.53)	.9927 (2.42)	1.012 (2.47)
CONSTANT	.0241 (.02)	1.353 (.85)	.2194 (.14)	2.063 (1.30)	1.949 (1.23)
$1/\sigma$	.2205	.2012	.1708	.1863	.1689
$P_v(Y>0 \mid x=\bar{x}$	.721	.768	.766	.795	.809
$E(Y \mid x=\bar{x}$	3.44	4.31	5.04	5.05	5.81
R^2	.254	.381	.336	.420	.389

TABLE 2-9

CCC Bidding Game Results
(|t| values in parentheses)

Dependent Variable	GCBC	GCAC	GCCE	REAC	RECE
# of OBS	53	53	53	53	53
# of Zero Bids	9	7	12	7	9
ED	.2548 (2.53)	.2188 (2.23)	.2307 (2.23)	.2741 (2.76)	.3103 (3.04)
A2534	.1269 (.22)	.0455 (.08)	-.1982 (.33)	.1219 (.22)	-.0268 (.05)
A3544	-.4698 (.79)	-.3478 (.59)	-.4378 (.74)	-.3902 (.66)	-.4532 (.77)
A4554	-.1444 (.24)	.3124 (.52)	-.4201 (.69)	.0377 (.62)	-.2329 (.38)
A55 +	.0480 (.08)	-.0223 (.04)	-.1085 (.17)	.0492 (.08)	-.0593 (.09)
INC	.0191 (1.93)	.0207 (2.10)	.0203 (2.04)	.0257 (2.58)	.0244 (2.43)
USTGC	.5742 (1.40)	.1107 (.27)	.7405 (1.79)	.5266 (1.29)	.6131 (1.49)
PSTGC	.1842 (.45)	.1413 (.34)	.3795 (.92)	.2283 (.56)	.2933 (.71)
SEX	-.9014 (2.09)	-.4648 (1.11)	-1.063 (2.42)	-.9284 (2.17)	-.8774 (2.05)
PRIM	1.197 (2.67)	.8802 (2.00)	1.315 (2.87)	1.179 (2.64)	1.240 (2.76)
CITPAY	.5292 (1.42)	.3928 (1.07)	.4160 (1.12)	.4651 (1.26)	.3737 (1.01)
USTPAY	.7941 (2.15)	-.8523 (2.35)	.8444 (2.26)	.8193 (2.26)	.9124 (2.47)
POLPAY	.4938 (1.45)	.5590 (1.66)	.4092 (1.20)	.4685 (1.39)	.5294 (1.56)
CONSTANT	-4.309 (2.45)	-4.222 (2.46)	-3.639 (2.01)	-4.663 (2.69)	-5.244 (2.93)
$1/\sigma$	.1367	.0744	.1302	.1110	.1084
$P_v(Y>0\|x=\bar{x}$	.615	.611	.610	.659	.638
$E(Y\|x=\bar{x}$	4.11	7.48	4.25	5.74	5.53
R^2	.518	.421	.506	.520	.510

valuations indicates an internal consistency among bids; on the average, people will pay more to get more. Finally, note that the R^2x100, the percentage of explained variation, ranges from a low of 25.4% on the GCAB bid of the AAA bidding game to 52.0% on the CCC bidding game. Relative to the OLS, tobit estimators seem to attain a better fit to the data. For the AAA checklist, tobit analysis does not appear to have improved our ability to discern significant decision variables. Results of the AAA bidding game appear rather similar to the checklist results. Results for the CCC bidding game (Ta.2-9) are substantially different from the other bid functions. Each of the a priori expectations regarding the positive effects of variables is confirmed. Education (ED), income (INC), and planned visits (USTGC) each affect valuations positively and very significantly. Expectation regarding the age variables are not confirmed. With regard to the shift (dummy) variables,(CITPAY) retains a positive sign and is consistent across all three data sets. USTPAY is again significant and demostrates the same positive effect that it had on the AAA checklist bids. POLPAY is also significant and positively related to bids as it was in the AAA bidding game. Finally, a respondent's sex (SEX) and whether or not the respondent was the primary income earner (PRIM) both appear to affect valuation--a result unique to the CCC bidding game.

Two propositions may be stated. First, tobit estimators appear to utilize the information contained within zero valuations more effectively and therefore result in superior estimation of bid function parameters. OLS failed to discern any systematic relationships in the CCC data whereas the tobit analysis uncovered several significant relations between dependent and decision variables. The effectiveness of tobit is also noticeable in the rather sizeable R^2's. Second, if only an average bid is of concern, then the method of eliciting bids, whether bidding game or checklist, may not significantly affect results. However, a contingent valuation design that accurately describes the decision

as well as forcing careful consideration of valuation will be more sensitive to individual variations. Such a design, therefore, may be more likely to permit discernment of systematic relation between individual dependent variables and individual decision variables.

The tobit procedure can glean information from some of the 0's. Tobit corrects biases that result from truncation of the dependent variable, but does nothing to solve the problem of individuals systematically refusing to participate in the bidding scheme. Thus, some of the 0's in the sample are informative, and some represent noise. Finding the right set of "Why 0 bid" questions is necessary to decide which observations should be deleted from the sample, and which 0's should be left in for the tobit estimation. A lower proportion of protesters among the 0 bids might explain why the tobit procedure was more successful than OLS in analyzing some sets of data.

2.3.3 Comparison of Empirical Results

2.3.3.1 Grand Canyon and Regional Park Visibility Programs

In the sections below the results of analyzing WTP data obtained by the Wyoming group for the NPS are presented. After removing invalid observations, about 85 percent of the NPS observations were left,* Of these, about 25 Percent were at the limit of the dependent variable (0 bids). Thus, a tobit model was chosen as the appropriate model for explaining the bid behavior. In a second stage, probit and OLS analyses were used.

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* The data for Albuquerque, Los Angeles and Denver were provided by the Wyoming group headed by William D. Schulze. The Chicago data were collected by us using methods identical to those used by the Wyoming group. The theoretical background for the survey and the results obtained by the Wyoming group can be found in Schulze, W. D. et. al. “The Benefits of Preserving Visibility in the National Parklands of the Southwest”, Office of Exploratory Research, U.S. EPA, Washington, D.C. (1981).

Ta.2-10, 2-2 and 2-12 are the most general relationships. All potentially relevant variables are included. We also allowed for non-linearities in income, age, education, and the electric bill. Income per family was restricted to a minimum of $5,000.

The common characteristics of the three tables are:

1) The "why zero" coefficient is negative as expected,but only the one that stands for "polluter should pay" and "other" is significant.

2) The non-white coefficient is negative but only barely significant.

3) Household size is mainly negative but is nowhere significant.

4) The quantitative variables which are assumed to have non-linear effects and are introduced by a linear and a quadratic term do exhibit non-linearity but mainly the coefficients are insignificant. Also the signs on the linear and quadratic terms are inconsistant across cities.

The possible combinations of coefficient and the implied effect are described below.

FIGURE 2-2

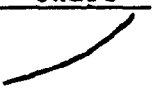
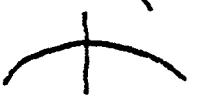
	Linear	Quadratic	Shape
1)	+	+	
2)	—	—	
3)	+	—	
4)	—	+	

TABLE 2-10
Grand Canyon Visibility Value-Tobit
Dependent Variable-The Grand Canyon Bid
(|t| values in parentheses)

CITY	LA	DEN	ALB	CHC	ALL
Total Ob.	127	110	115	98	450
Valid Ob.	118	103	99	68	388
Limit Ob.	19	33	24	16	92
Urban Dummy	..0452 (.14)	-.1334 (.42)	-.4539 (1.70)	-.0243 (.08)	-.0727 (.53)
Female Dummy	.4442 (2.03)	-.0324 (.13)	.0403 (.17)	.2607 (.86)	.2029 (1.74)
NonWhite Dummy	.2605 (.97)	-.5969 (1.52)	-.3099 (.99)	-.0676 (.20)	-.1477 (1.04)
Why O-Not Significant Difference.	-3.439 (.2)	-6.658 (.01)	-.5214 (.75)	-.1162 (.10)	-1.054 (2.43)
Why O-Other	-1.205 (4.27)	-2.633 (6.00)	-1.352 (4.22)	-1.490 (3.76)	-1.448 (8.90)
Education	1.162 (2.01)	-.2510 (.39)	0.8872 (1.46)	-.3522 (.48)	-.1319 (.45)
$(Edu)^2$	-.0370 (1.89)	.0064 (.29)	.0351 (1.63)	.0103 (.40)	.0450 (.45)
Age	..0515 (.83)	-.0867 (1.24)	-.1329 (1.74)	.0950 (1.00)	.0135 (.39)
$(Age)^2$	-.0007 (.98)	.0010 (1.15)	.0015 (1.64)	-.0012 (1.07)	-.0003 (.64)
Household Size	.0788 (1.26)	-.0784 (.82)	-.0003 (.003)	-.0916 (1.08)	-.0548 (1.50)
Income	-.0612 (3.09)	-.0044 (.20)	0.759 (1.45)	-.0040 (.11)	-.0054 (.48)
$(Income)^2$	.0009 (3.94)	.0000 (.10)	-.0018 (1.66)	.0002 (.36)	.0001 (1.06)
Electric Bill	.0619 (1.20)	.0076 (.73)	-.0311 (1.57)	-.0062 (.29)	.0008 (.14)
$(Electric\ Bill)^2$	-.0002 (1.62)	-.0000 (.57)	.0003 (1.98)	.0000 (.33)	.0000 (.07)
Constant	-8.751 (1.62)	5.261 (1.04)	8.718 (1.80)	1.890 (.33)	1.674 (.74)
$D(Y < 0 \mid x = \bar{x})$	.608	.486	.495	.476	.498
$E(Y) \mid x = \bar{x}$	5.59	2.13	4.53	9.87	5.95
LLF	-337	0224	-297	-249	-1026
R^2	.319	.297	.267	.096	.075
LA					-.194 (1.1)
Den					-.480 (2.67)
Alb					-.228 (1.27)

TABLE 2-11

Grand-Canyon Visibility Study
Dependent Variable-The Regional Park Bid
(|t| values in parentheses)

CITY	LA	DEN	ALB	CHC	ALL
Total Ob.	127	110	115	98	400
Valid Ob.	118	103	99	68	388
Limit Ob.	23	39	90	21	113
(D) Urban	.2434 (.70)	-.3096 (.93)	-.8654 (2.94)	.2747 (.83)	-.1600 (1.11)
(D) Female	.3690 (1.65)	-.3506 (1.31)	.0394 (.15)	.1031 (.30)	.1513 (1.23)
(D) NonWhite	-.1237 (.40)	-.2854 (.72)	-.2455 (.70)	-.3008 (.77)	-.3037 (2.04)
Air Quality N.S.	-3.451 (.21)	-6.458 (.01)	-5.801 (.01)	-5.679 (.00)	-6.350 (.01)
Other	-1.402 (4.73)	-3.013 (5.88)	-3.116 (3.78)	-10.152 (.03)	-1.998 (9.65)
Education	.4351 (.78)	-.9061 (1.35)	-1.871 (2.80)	.2297 (.26)	-.7083 (2.36)
$(Edu)^2$	-.0129 (.69)	.0298 (1.30)	.0667 (2.83)	-.0102 (.34)	.0242 (2.35)
Age	.0921 (1.48)	.0512 (.72)	-.1500 (1.86)	.2228 (1.98)	-.0180 (.51)
$(Age)^2$	-.0012 (1.66)	-.0007 (.85)	.0016 (1.65)	-.0027 (2.01)	-.0004 (.85)
Household Size	-.0349 (.56)	-.0488 (.50)	-.0846 (1.03)	-.0648 (.67)	-.0121 (.34)
Income	-.0467 (2.32)	.0171 (.75)	.1150 (1.88)	-.0881 (1.22)	-.0080 (.69)
$(Income)^2$	.0007 (2.95)	-.0002 (.92)	-.0026 (2.05)	.0010 (1.69)	.0002 (1.28)
Elec. B.	.0267 (1.86)	.0082 (.77)	-.0417 (.89)	-.0270 (1.05)	.0020 (.32)
$(Elec.\ B)^*$	-.0002 (1.97)	-.0000 (.63)	.0005 (2.35)	.0003 (1.41)	.0000 (.70)
Constant	-4.719 (1.12)	7.009 (1.33)	16.762 (3.13)	-3.646 (.52)	5.510 (2.37)
$P(Y > 0 \mid x = \bar{x})$	.573	.438	.240	.009	.393
$E(Y) \mid x = \bar{x}$	5.086	1.418	1.756	.035	3.458
LLF	-364	-194	-273	-188	-783
D^2	.320	.350	.495	.463	.146
LA					.0903 (.49)
Den					-.3580 (1.88)
[illegible]					-.0352

TABLE 2-12

Grand Canyon Visibility Value-Tobit
Dependent Variable-The Plume Bids
(|t| values inparentheses)

CITY	LA	DEN	ALB	CXCH	ALL
Total Ob.	127	110	115	98	450
Valid Ob.	118	103	99	68	388
Limit Ob.	35	37	36	23	131
Urban (D)	-.0110 (.03)	-.3126 (.98)	-.4935 (.81)	-.0189 (.061)	-.2239 (1.60)
Female (D)	-.2236 (1.57)	.1147 (.44)	.0448 (.201)	.0820 (.201)	.1229 (1.03)
NonWhite (D)	-.2236 (.82)	-.9724 (2.25)	-.2670 (.81)	-.2388 (.70)	-.3313 (2.22)
Air Quality N.S.	-3.296 (.38)	-6.468 (.08)	-.1515 (.22)	-3.481 (.26)	-.7502 (1.68)
Other	-1.363 (4.7)	-2.335 (.57)	-1.292 (.375)	-1.569 (3.72)	-1.474 (8.86)
Education	-.6434 (1.12)	-1.298 (1.97)	-1.375 (2.18)	-.7034 (.94)	-.8716 (2.98)
$(\text{Education})^2$	.0201 (1.04)	.0445 (1.97)	.0528 (2.38)	.0217 (.93)	.0300 (2.97)
Age	.0511 (.82)	-.1040 (1.47)	-.1279 (1.61)	.0074 (.08)	-.0339 (.30)
$(\text{Age})^2$	-.0008 (1.03)	.0011 (1.34)	.0015 (1.54)	-.0001 (.10)	.0003 (.67)
Household Size	.0691 (1.09)	-.0378 (.34)	.0030 (.04)	-.1147 (1.29)	-.0197 (.55)
Income	.0282 (1.40)	.0136 (.64)	.0800 (1.45)	.0096 (.27)	.0141 (1.22)
$(\text{Income})^2$	-.0004 (1.64)	-.0001 (.57)	-.0018 (1.60)	.0000 (.10)	-.0002 (1.32)
Electric Bill	.0046 (.35)	-.0010 (.10)	-.0426 (2.03)	-.0039 (.17)	-.0060 (.99)
$(\text{Electric Bill})^2$	-.0000 (.2)	.0001 (.14)	.0004 (2.27)	.0001 (.43)	.0001 (1.30)
Constant	4.207 (.98)	12.305 (5.21)	11.846 (2.38)	5.938 (1.01)	7.587 (3.32)
$?(Y > 0 \mid x = \bar{x})$	.602	.435	.416	.463	.473
$E(Y) \mid x = \bar{x}$	2.580	1.579	3.345	3.041	3.239
LLF	267.7	206.9	263.4	109.3	980.3
R^2	.216	.255	.309	.129	.103
LA					-.0524 (.46)
Den					-.1547 (1.37)
Alb					.0454

Cases 1) and 2) never occurred. We consider the permissible range for case 3) to be to the left of the dividing line and a priori do not have expectations for case 4). Note that the turning points are at values of the independent variables that are $\hat{a}/_{2\hat{b}}$ where $\hat{a}$ is the estimated coefficient of the linear tern and $\hat{b}$ of the quadratic term. Given the range of the variables, which is representative of the U.S. population, the estimated turning points in many cases are outside the range. The common conclusions for the three tables are related to the relevant range:

a) Education effect on the bid is positive although there might be a cut-off point (e.g. Ta. 2-9, Albuquerque 12 years).

b) Age effect is negative. It might be pronounced for ages above the cutting point. Thus for age the common picture is the right side of 3) and the left side of 4) in Fig.2-1.

c) Income has a similar effect as education.

d) The electric bill has a similar effect as income.

The final conclusion is related to the, question whether the observed behavior is the same in the four cities. The similarity is related only to the marginal propensities of the explanatory variables (city effects are accounted for by a city dummy variable). The answer is negative*. Searching for reasons for the insignificance of coefficients led to the possibility of multi-colinearity. This might arise due to the inclusion of both linear and quadratic terms and also due to potential expected (although non-linear) relationships between income on one side and education, age and race on the other side. One would also expect a positive relationship between income and the electric bill.

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* Based upon an F test on the residuals sum of squares (the Chow test).

Concerning city and variable results, we find that they are consistant. The consistancy is exhibited in the each city equation for each bid. The results are similar in nature. One might argue that this is to be expected since the explanatory variables are the same. While this is a fact,the consistancy of the estimated coefficients would not hold if the bids were not consistant. Hence, the three bids are not independent. Although each is expressed one at a time, they are motivated by the same reasons and affected by the same random errors. Thus, from the econometric point of view a "seemingly unrelated tobit model" is the appropriate model (does not exist).

2.3.3.2 Analysis of User Valuations

The analysis of user data is limited to those that visited or planned to visit the Grand Canyon. Thus, one expects them to be capable of better evaluating visibility in the western parks. The model and method of analysis are the same as the cities results reported above. The explained bid is for a specific improvement of visibility.

The various results presented in Ta. 2-13, 2-14 and 2-15 are strikingly consistent with this pattern of insignificance in the coefficient of "planned days at the Grand Canyon"; the coefficients of this variable are significant in almost all runs. Furthermore, the log likelihood ratio indicates that none of the probit runs is significant at the .05 level.[1]

Reviewing the probit analysis, neither rural residence, sex, nor race of the respondent is significantly related to the probability of a positive bid. Metropolitan location, specifically residence in Los Angeles, did in some cases affect the probability of a positive bid relative to residence in Albuquerque.[1] The coefficient for Denver (dummy) is always insignificant. Neither age nor education is significantly related to positive bids although.

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[1]The log likelihood ration in each probit runs is less than the critical y[2]

TABLE 2-13

Coefficients of the Model Explaining Positive Bids

(Probit Analysis)

Indep \ Dep.(3)	GCAB (14)[1]	GCAC (10)	GCAD (9)	GCAE (7)	RPBC (17)	GCPL (11)
Rural(D)	2.223 (5.44)[2]	2.780 (8.20)	2.635 (9.06)	2.530 (9.57)	2.660 (5.40)	2.358 (5.42)
Female (D)	.0738 (0.36)	-0.0459 (0.42)	0.0536 (0.44)	0.6032 (0.54)	-0.0042 (0.34)	0.6353)0.43)
Non-White (D)	.3705 (0.45)	0.1558 (0.48)	-0.0094 (0.49)	0.1440 (0.58)	0.8500 (0.52)	0.5359 (0.55)
Los Angeles (D)	1.229 (0.53)	1.073 (0.57)	0.9095 (0.58)	0.3987 (0.61)	0.8072 (0.47)	0.9781 (0.55)
Denver (D)	.1866 (0.37)	-0.2148 (0.44)	-0.3338 (0.44)	-0.6158 (0.51)	-0.2898 (0.37)	-0.097 (0.39)
Education (Yrs.)	.0055 (0.007)	-0.0077 (0.08)	-0.0033 (0.08)	-0.0190 (0.09)	0.0701 (0.071	-0.0082 (0.08)
Age (Yrs.)	-0.0049 (0.01)	-0.0013 (0.02)	-0.0063 (0.02)	-0.0043 (0.02)	0.0054 (0.01)	0.0042 (0.01)
Income ($1000.00)	-0.0118 (0.01)	-0.0148 (0.0;)	-0.00141 (0.01)	-0.0163 (0 . 0 1)	-0.0173 (0.01)	-0.0164 (0.0.)
Days Visited G.C. (#)	0.0578 (0.05)	0.2917 (0.16)	0.3036 (0.17)	0.2235 (0.161		0.1069 (0.08)
Planned Days To visit G.C. (#)	0.0983 (.07)	0.1169 (0.08)	0.0950 (0.09)	0.0560 (0.08)		0.0713 (0.07)
Constant	0.8025 (1.30)	0.7458 (1.58)	1.394 (1.65)	2.021 (1.70)	0.1978 (1.14)	0.3135 (1.4)
-2LLR	18.0	16.9	15.4	13.6	17.5	17.76

[1]Number in parentheses Indicates number of zero bids out of 147 cases.

[2]Standard errors noted in parentheses underlying estimated coefficients.

[3]GCAB = Improving the value of visibility in the Grand Canyon from level A to level B.
GCAC = As above from level A to level C.
GCAD = As above from level A to level D.
GCAE = As above from level A to level E.
RPBC = As above but for the regional parks from level B to level C.
GCPL = As above but for the Grand Canyon removing the plume.

TABLE 2-14

Bid Analysis Coefficients for Positive Bids

(OLS)

Dep.[1] / Indep.	GCAB	GCAC	GCAD	GCAE	RPBC	GCPL
Rural (D)	0.4131 (0.79)	0.4180 (1.25)	0.645 (1.65)	0.1337 (2.51)	0.1189 (1.81)	-0.0892 (1.92)
Female (D)	-0.2600 (0.31)	-0.6547 (0.49)	-1.058 (0.65)	-1.514 (0.99)	-0.0119 (0.68)	0.1142 (0.75)
Non-White (D)	-0.4432 (0.37)	-0.8512 (0.58)	-0.9147 (0.77)	1.487 (1.17)	-0.9846 (0.80)	-0.8794 (0.88)
Los Angeles(D)	0.2001 (0.35)	0.4361 (0.55)	0.5371 (0.72)	0.5029 (1.1)	0.8181 (0.761)	0.2889 (0.83)
Denver (D)	-0.0135	0.1511 (0.65)	0.5096 (0.86)	-0.2747 (1.31)	-0.7337 (0.92)	0.8039 (0.99)
Education (Yrs.)	-0.0405 (0.07)	-0.0228 (0.12)	-0.0716 (0.15)	-0.1041 (0.23)	0.0040 (0.16)	0.0604 (0.18)
Age (Yrs.)	-0.0098 (0.01)	-0.0249 (0.02)	-0.0361 (0.02)	-0.0761 (0.04)	-0.0251 (0.02)	-0.0554 (0.03)
Income ($1000.00)	0.0076 (0.01)	0.0136 (0.01)	0.0240 (0.02)	0.0251 (0.03)	-0.0365 (0.02)	-0.0254 (0.02)
Days Visited G.C. (#)	0.0216 (0.04)	-0.0356 (0.06)	-0.0788 (0.081)	0.0171 (0.12)		0.0282 (0.09)
Planned Days To Visit G.C. (#)	0.0315 (0.04)	0.1042 (0.06)	0.2079 (0.07)	0.2816 (0.11)		0.2027 (0.09)
Constant	2.534 (1.09)	3.611 (1.73)	5.213 (2.27)	9.041 (3.46)	5.042 (2.39)	4.587 (2.62)
R^2	0.064	0.103	0.142	0.161	0.238	0.162

[1] See notes to Table 7.

TABLE 2-15

Coefficients of the Normalized Index of Bids

(Tobit Analysis)

Dep.[1] / Indep.	GCAB(14)	GCAC (10)	GCAD (9)	GCAE (7)	RPBC (17)	GCPL (11)
Rural (D)	0.3617[2] (0.47)	0.2614 (0.47)	0.2713 (0.47)	0.0899 (0.47)	0.3300 (0.50)	.0885 (.47)
Female (D)	-0.1186 (0.17)	-0.2266 (0.18)	-0.2708 (0.18)	-0.2375 (0.17)	-0.0257 (0.18)	.0981 (.17)
Non-White (D)	-0.1209 (0.21)	-0.2224 (0.20)	-0.1835 (0.20)	-0.1444 (0.21)	0.0428 (0.21)	-.1101 (.21)
Los Angeles (D)	0.3345 (0.20)	0.3444 (0.20)	0.3069 (0.20)	0.2051 (0.20)	0.4325 (0.20)	.2124 (.20)
Denver (D)	0.0045 (0.22)	0.1181 (0.22)	0.1467 (0.22)	-0.0360 (0.22)	-0.2019 (0.24)	.2065 (.22)
Education (Yrs.)	-0.0214 (0.04)	-0.0025 (0.04)	0.0073 (0.04)	-0.0089 (0.04)	0.0257 (0.04)	.0120 (.04)
Age (Yrs.)	-0.0065 (0.006)	-0.0092 (0.006)	-0.0112 (0.006)	-0.0136 (0.006)	-0.0036 (0.006)	-.0124 (.016)
Income ($1000.00)	-0.0013 (0.005)	0.0011 (0.005)	0.0023 (0.005)	-0.0001 (0.005)	-0.0156 (0.005)	.0096 (.001)
Days Visited G.C. (#)	0.0178 (0.02)	-0.0058 (0.02)	-0.0131 (0.02)	0.0077 (0.02)		.0111 (.02)
Planned Days To Visit G.C. (#)	0.0324 (0.02)	0.0487 (0.02)	0.0657 (0.02)	0.0630 (0.02)		.0625 (.02)
Constant	1.171 (0.54)	1.082 (0.59)	1.211 (0.61)	1.427 (0. 1)	0.734 (.57)	.9384 (.61)
$\frac{1}{\sigma}$	0.5965 (0.037	0.3881 (0.024)	0.2948 (0.018)	0.1966 (0.012)	0.2344 (.019)	.2588 (.016)
$P(Y>0\|X = \bar{x})$	0.833	0.043	.861	.865	.808	.816
$E(Y\|X = \bar{x})$	1.77	2.80	3.92	5.95	2.49	3.867
R^2	0.073	0.112	0.148	.160	.143	.177

[1] See notes to Table 7.

[2] Coefficients estimated are $\frac{\beta}{\sigma}$

the age coefficient is at least consistently negative. The income coefficient is also consistently negative though insignificant. The number of days a respondent has spent at the Grand Canyon is close to being significantly related to positive bids. The number of days to be spent at the Grand Canyon in the future is not significantly related to a postive bid.

The OLS analysis attempts to estimate the behavioral structure of bids for those who bid a positive amount. Coefficients for the rural, race, metropolitan area, education, age, income, and days visited variables are consistently insignificant. The age coefficient, though insignificant, is again consistently negative. Planned days to be spent at the Grand Canyon is, however, significantly related to the magnitude of the bid. For each day planned, the bid on AC rises by 10¢, that on AD by 21¢, that on AE by 28¢ and that on the plume by 20¢. In each case, R^2's are very small.

Results of the tobit analysis are only slightly more revealing. As with the OLS, most coefficients remain insignificant. Age, however, is significantly negative with respect to the magnitude of bids. The income coefficient, where significant, is negative. Planned days to be spent at the Grand Canyon is in three out of four cases highly significant. Considering the equation as a whole, the R^2 's again tend to be low. However, the predicted bids conditioned upon mean values for the independent variables are consistently increasing, as the conceptual structure of the bid curve would suggest. This consistency suggests that the bids were determined by a systematic method. Furthermore, predicted probabilities of a positive bid, conditioned upon mean values, tend

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[1]Albuquerque is defined to be the base city.

to correspond well with actual sample results. Thus, while the significance of the coefficients may not be very satisfying, the equations do seem to predict fairly well at average levels.

The Regional Parks tobit equation was also estimated for the case where the sum of past visits and sum of planned future visits to all Western Parks were the explanatory variables. The variable means are correspondingly 7.5 9.9 and they range from 0 to 80 and 0 to 60. The tobit equation does not change compared to the previous one. Also, the coefficient of the sum of past visits tends to be insignificant while that of future planned visits is postive significant. (-.0061 (.009) and .0223 (.008) respectively)

$$P(y>0|x=\bar{x}) = .776$$

$$E(y) \mid (x=\bar{x}) = 3.347$$

$$R^2 = .137$$

In the corresponding probit equation the visit variables have coefficients below their standard errors. The -2LLR is 14.9 with 10 D.F., which implies that the equation is not significant.

When analyzing the user survey we also looked at a model in which the answers for "Why a zero bid" were explicitly included as explanatory variables The coefficients of these variables (dummies) are always significant and negative. Thus obviously the R^2 is higher than in analyses without these variables. The explanation by other variables, mainly age and income, is some what better, although income never emerges as an important variable. The other socio-economic variables, including city effects,do not become more pronounced. The only exception is race. In several cases, being non-white results in significantly lower indexes (the tobit normalized coefficient); the coefficient of being non-white (dummy) is negative and significant.

The final run of the users survey data was an attempt to directly construct a bid curve. The variables to be explained are the differences in the bids, i.e., the vertical differences along the indifference curve in Fig. 2-3.

Future visits are important, although not always significant. The consistently significant variable is the height of the starting level of the bid. This is another clue for the consistency of the valuation of visibility.

Age is significantly negative while income has no effect. The same holds for education. City dummy variables and sex, race, rural-urban dummy variables have unstable coefficients. In most cases their standard error of estimate is larger than the corresponding coefficient.

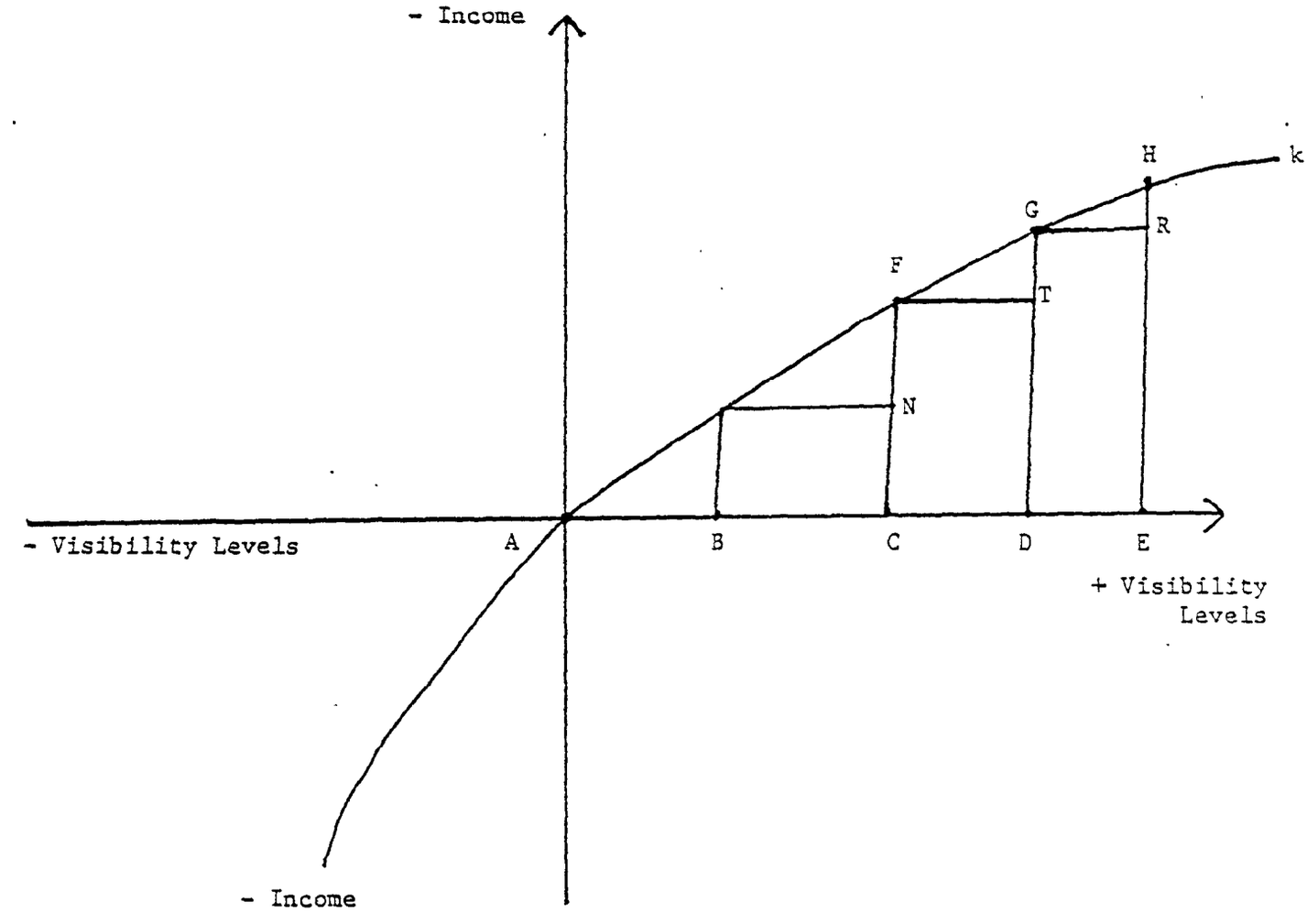
Overall, two observations can be made. First, the coefficient of the explanatory variables, with only an occasional exception, are insignificant. Second, predicted bids across increments in visibility are consistent. The implications that can be drawn are that the knowledge and perception of the population affected the quality of their answers. Those that have not been in the western parks and do not intend to be there in the future are likely to have less information about them than those that have either visitied or plan to visit.

Deficient information does not relate only to what one expects to see but mainly to the costs involved in getting there, the time required, the effort and effect of the weather on enjoyment. Those that have less information make decisions under greater uncertaintly where the distribution of perceptions they are drawing from is not stable.

The amount of information available differs depending upon whether they have already visited or plan to visit. The idea that these differences will cause their bids to change was tested by estimating separate relationships

FIGURE 2-3

The Bid Curve (AK)*



* In the analysis, the vertical segments FN, GT and HR are the explained variables.

for each group (Ta.2-16). The disadvantage with this approach is that the sample sizes are small, which is important given that we employ a maximum likelihood estimation procedure. Note the distance effect for Chicago. Hence, everything else the same, the information is low and the expected variance in the bids large (row 4 of Ta.2-16). On the other hand, comparison of means and variances of other population characteristics indicates considerable similarities (e.g., income, the last two rows of Ta. 2-16).

TABLE 2-16

Distribution of Bidders by Status
w.r.t. Visits to the Grand Canyon
(percent)

	LA	Denver	Alb.	Chc.	All
Visited	28.8	31.4	41.4	21.7	31.4
Plan to Visit*	80.5	71.4	74.7	68.1	74.4
Mean Bid	4.98	3.79	3.78	7.64	4.83
Std. Dev.	10.9	5.4	11.5	25.5	13.8
Mean Income	29.0	32.0	20.7	30.0	28.0
Std. Dev.	20.1	20.2	10.5	17.5	18.2

* Contains also those that visited in the past.

2.4 VISIBILITY VALUE FUNCTION

2.4.1 Overview to Section 2.4

The visibility value function was the concern of all of Section 2 research. The function embodies important results of this research and extends them in significant ways. The theory of household production, fundamental to the development of the CV instrument, was equally important to the development of the visibility value function. The importance of regional, or spatial economics was recognized from the beginning of the Project. However, the spatial dimension receives its most complete formulation in the work of Section 2.4.

The spatial problem was how best to use evidence from six cities to measure the value of visibility improvement in the entire eastern U.S. The earliest solution to the problem, as reported in Section 2.2 for example, was to regress measures of willingness to pay for each separate program on social and demographic variables . This would lead to a regression equation for each CV program in each city. For example, willingness to pay (WTP) for a ten mile improvement in Atlanta would be estimated separately from WTP for a twenty mile improvement in Atlanta. Similarly, there was no hypothesis about what a ten mile improvement in Atlanta would be worth to residents of Mobile, as distinct from Chicago's WTP for the Atlanta improvement. WTP statements were modelled as if people regarded the East as a spatially undifferentiated area.

Spatial differentiation is introduced by the visibility value function in Section 2.4. It modelled WPT for regional improvements as directly proportional to the area of improvement in square miles and inversely proportional to distance from the improvement. This specification permitted valuations of

different hypothetical programs in the CV exercise to be treated as data underlying a single demand curve. The implication for policy application in Section 4 was that a regional visibility policy, which produces numerous geographically dispersed improvements, can be evaluated by means of a single visibility value function. The spatial aspects of behavior and the substitute nature of visual air quality in different locations established in Section 2.1.4, were explicitly modelled. In addition, by pooling the data and estimating a single equation, more precise parameter estimates were obtained.

We have seen in the previous section that households were willing to pay less for visibility-improving program when presented at the end of a series of similar programs then when presented alone to the respondents. In this section a model is developed which accounts for this behavior and allows the construction of a general visibility value function which can be used to estimate aggregate benefits of a wide variety of policy scenarios.

A central feature of the model is its direct incorporation of spatial relationships into the empirical specification. In order to make meaningful statements about these spatial relationships an expanded data sample was gathered from the metropolitan areas in and around six major cities in the eastern United States. The iterative bidding game technique was again used for this purpose, although it was somewhat modified to reduce confusion found among some respondents. As before, a large amount of socioeconomic data and data on household participation in liesure activities were also gathered. More complete description of this dataset follows later in this section. First. we will develop more fully the conceptual framework that is used to analyze the problem at hand.

2.4.2 Visibility in Household Production

Visibility is primarily a spatially-distributed public intermediate good in the framework of household production and consumption, although there may be important effects from the direct entry of visibility into the utility functions of individuals as an amenity. In the household production analy-

sis, visibility is combined with other factors of production such as scenery, eyeglasses, telescopes, and other human and physical capital such as astronomy classes or picture windows, to produce a service or “commodity” which enters into the utility function of the individuals.

The individual’s demand for visibility is, in this framework, formed by the vertical summation of the derived demand curves for visibility from each commodity. The market demand is the vertical summation over individuals of these demand curves, thus representing a second level of aggregation.

For the remainder of this analysis, the first level of aggregation, that of each individual over the array of utility producing commodities, will be summarized under the heading "visual services." Our goal is to explain variation in household demand for visual range (VR) based on the household’s stock of other inputs of production of visual services (VS), income, and current consumption of VS. This latter variable is important since the demand being measured is the marginal or net demand, given an initial endowment of VS and other goods and services.

To make sense of a household’s demand for increments in visibility we need to establish some way of quantifying VS which is consistent with economic theory. For our purposes it is not sufficient to say that a certain person in Chicago consumes visibility of, say, twelve miles, for this statement would ignore altogether how the value of these twelve miles might differ for, as an example, a poor-sighted individual in a basement apartment and a keen-sighted owner of a high-rise condominium with a spectacular view and a telescope mounted on the balcony. In addition, using local VR as a measure of a household’s consumption of VS would ignore completely the value of nonlocal visibility, which we have seen and will see again in this section has value to households as they have expressed by their willingness to pay for increments in nonlocal VR. This latter effect is of critical importance in the analysis of the social value of visibility improvements because sometimes

areas receiving visibility protection might have few if any permanent inhabitants, and so a measure of VS which did not allow for nonlocal effects would place a zero value on these areas when our common sense tells us otherwise.

To get a better understanding of the spatial nature of VS we will draw an analogy from a more commonplace example of the same kind of economic structure, that of urban parks. If we require an estimate of the social value of an additional lakefront park in the City of Chicago, for instance, we would want to know where the park would be located, where the population is located, the current distribution of parks and park facilities, and lastly any unique site-specific features of the new park. We can abstract somewhat and think of each household as facing an array of parks distributed on a two-dimentional plane with the household at the origin. Each park has a certain amount of facilities and scenery, which can be thought of as a measure of quality, and each park has some unique characteristics. We should expect some basic properties to hold in this framework. First, it is reasonable to suppose that for a given park there are diminishing returns to quality. Second, the value of a given park to a given household will be negatively related to the distance between the residence and the park. Lastly, the value of the new park would be lower for households already in close proximity to parks than for households very distant from all parks, controlling for the other characteristics.

A measure of park consumption would then need to add all available park acreage, but only after weighting in some way each park according to its distance from the household and its quality. Similarly, a measure of visibility consumption should add together visibility in all places, but weighting each place's contribution by its distance, scenery, and quality. In particlular we define a function relating VS to these variables as

$$VS_j = \sum_i VR_i^{\alpha 1} SM_i^{\alpha 2} D_i^{\alpha 3} SC_i^{\alpha 4} \quad , \tag{2-39}$$

where VS_j is household j's consumption of VS, VR_i is visual range in state i, SM_i is the area of state i in square miles, D_{ij} is the distance between household j and the center of state i, and SC_i is a measure of scenery in state i. The summation is done for the "continental" United States, including the District of Columbia. D_{ii}, the own-state distance is approximated by half the radius of a circle which would have area SM_i, or

$$D_{ii} = \tfrac{1}{2}\sqrt{1/\pi} \cdot \sqrt{SM_i} \qquad (2\text{-}40)$$

Although it might be possible to construct a proxy for SC , no such proxy is both convincing and readily available. Therefore, for the remainder of this analysis SC will be set equal to one for each state, equivilent to the assumption that each state has an equal amount of unique scenery. In addition, the following simplifications will be used:

1. All states west of the Mississippi River are combined into a single "super-state" centered near Denver.
2. The paramenters α_1 and α_2 from eq. (2-39) will each be fixed at unity.

The value of the remaining parameter α_3, the exponent on distance, will be estimated jointly with the vector of household characteristic parameters, as will be discussed below.

The current distribution of visibility as calculated by Trijonis is shown in Fig. 2-4. The isopleth map represents lines of equal VR at nonurban locations. Based on the data contained in this map, each state is assigned an initial level of VR. For additional information on this data and application of this distribution to the estimate of actual program benefits see the expanded discussion in Section 4 of this report.

2.4.3 Basic Properties of Visibility Valuation

Each household is assumed to have a well-defined, continuous, and mono-

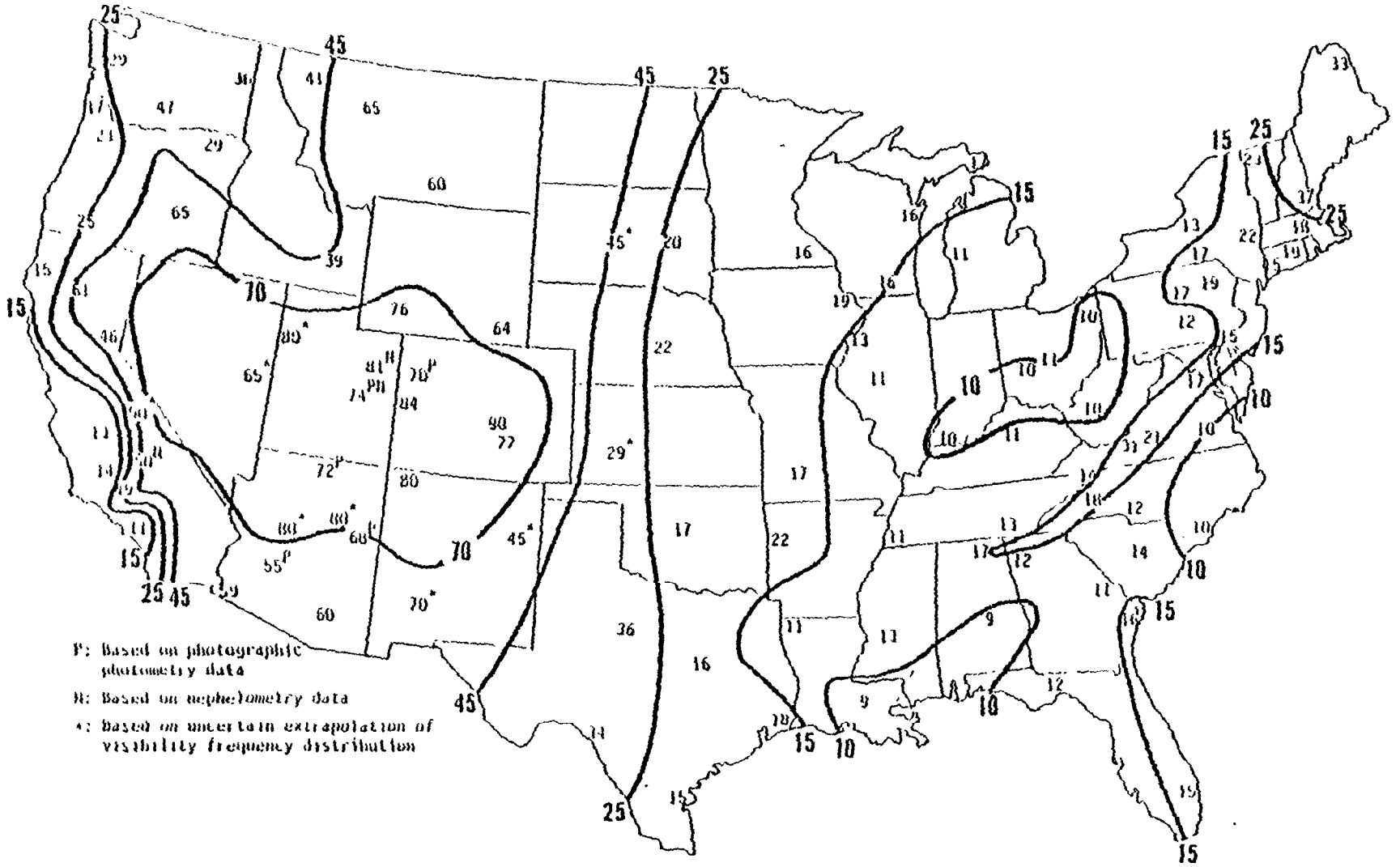


FIGURE 2-5. Median yearly visibilities and visibility isopleths for suburban/nonurban areas.

Source: Trijonis and Shapland, 1979

tonic increasing total benefit curve for VS. In Fig. 2-6a such a carve is shown. For a given household at a given moment, VS is fixed exogenously at VS^0. The total benefit at this level of VS is also shown in Fig. 2-6a. These two quantities determine the "endowment point" of VS and all other goods which we are measuring in dollar bundles along with the benefits of VS. These two lines become the axis for the marginal bid curve merely by rescaling the old axis. The only non-trivial point is that we do not know the original scale or the total benefit curve. All we can observe is the benefit from changing visibility from its present level as Fig. 2-6b for any individual.

Being a simple transformation of the total benefit curve, the marginal benefit curve, or bid curve, has the following properties:

Property 1: $BID(0)=0$
Property 2: $BID'(\Delta VS)\geq 0$
Property 3: $BID''(\Delta VS)\leq 0$
Property 4: Limit $BID'(\Delta VS)=0$ as $\Delta VS \to \infty$

It is important to note that some individuals will be at a point on their total benefit curve such that the slope of the bid curve is not significantly different from zero over the range of VS which is encountered by the respondent during the iterative bidding procedure. This does not imply, of course, that the individual does not value visibility, just that total benefits are some arbitrary constant over the relavent range.

As we have seen, for a given individual the marginal value of visibility (or VS) declines as total consumption increases. We might therefore expect that households in high VS cities bid less for increments in VS than do households in low VS cities, controlling for income and all the other fac-

FIGURE 2-6a

Total Benefit Function

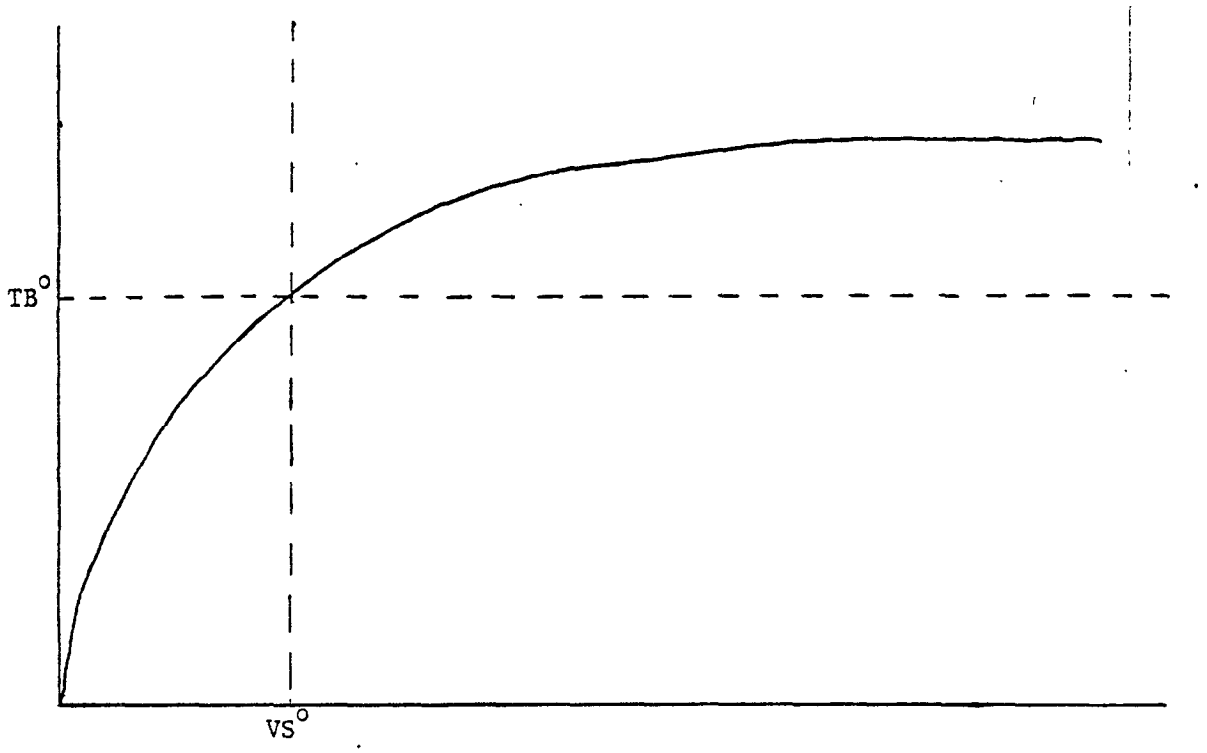
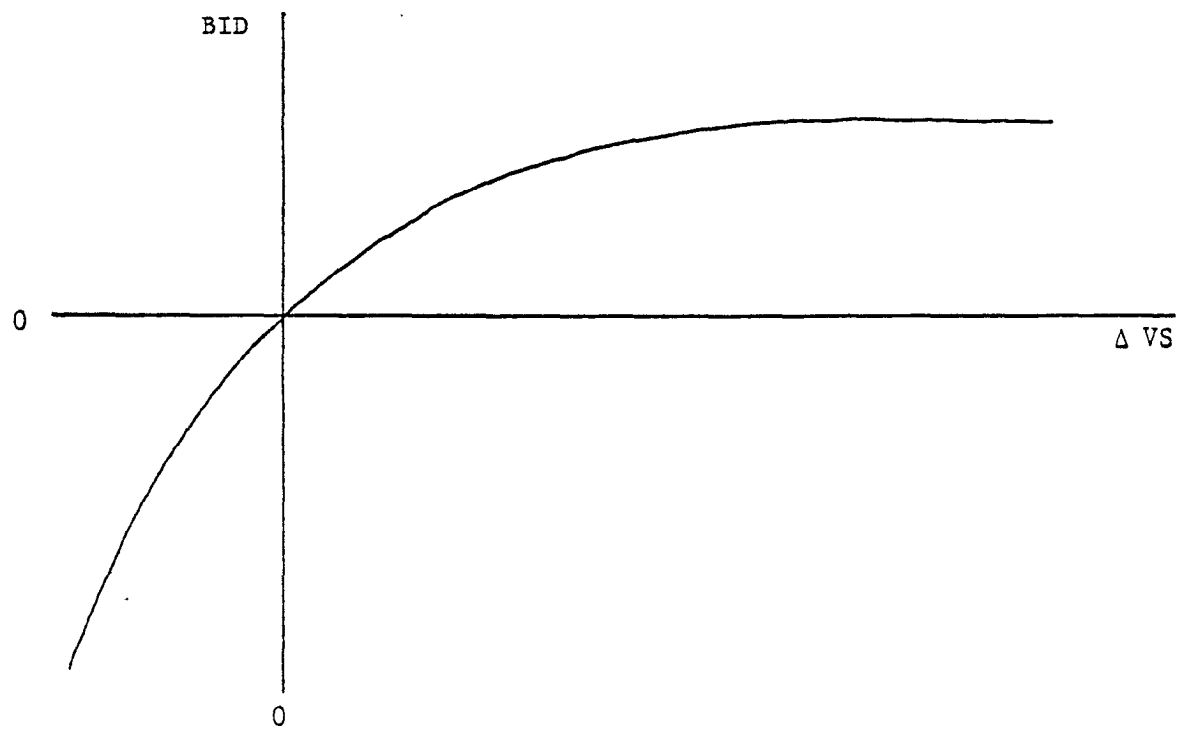


FIGURE 2-6b

Benefits of Changing Visibility from Present Level



tors. Such an expectation cannot be sustained, however, as long as the population is not homogeneous with respect to household demand for VS.

Once we acknowlege a heterogeneous population we must recognize that there will be some tendency of individuals to sort among the cities according to their demands for VS (and other amenities, of course). Thus, at the margin an extra mile of VR might be worth more to the average household in the high-VS city than the corresponding household in the low-VS city. This effect is reinforced by the additional tendency of households in low-VS cities to specialize their human and physical liesure capital in activities not visibility-intensive, such as indoor recreational facilities and training. Households in these areas might also spend resources on other factors of production, such as a residence with a glorious view of a nearby park or garden, as opposed to a household in a high-VS area investing in a residence with a view of a distant vista. Thus, even if the marginal product of VR is higher when the initial level of VR is low, it may be the case that the value of this marginal product may be rather low, especially in the short-run when households are even less able to adjust some other factors of production.

Since we will be examining a cross section of only six cities any estimate of this reduced-form effect of the level of initial visibility should be treated with some caution, although it remains an interesting and important parameter in the bid function.

2.4.4 The Visibility Value Function

We now turn to the empirical specification and estimation of the visibility value function (VVF). We require for this a functional form consistent with Properties 1-4 and capable of handling both continuous and discrete explanatory variables. This is not a simple matter. A normal OLS regression. even without an intercept term, will violate Property 1 if simple dummy

variables are used. Also, a dummy variable for a discrete effect will not be correctly specified, since we know from Fig. 2-6b that a variable which tends to increase bids for positive changes in visibility will neccessarily tend to decrease (increase in absolute value) bids for negative increments in visibility.

What is needed is a functional form which has Properties 1-4 and which allows the bid curve to pivot around the origin with changes in the vector of explanatory variables while preserving these properties. Such a form is suggested by the "negative exponential growth" function, which we adapt as

$$BID=[1-\exp(-\gamma\Delta VS)] \quad , \tag{2-41}$$

which is monotonic increasing, passes through the origin, and has an upper limit of +1 (for all positive values of Y). This gives us our prototype bid function. We now need to include a rotational vector of household characteristics H, where

$$H=(\alpha+\Sigma\beta_i Z_{ij}+u_j) \quad , \tag{2-42}$$

so that H is a linear combination of these characteristics Z, and there is an unexplained household-specific rotational parameter u .

Our complete empirical bid curve is then given by the product of these two terms to form

$$BID_j = [1-\exp(-\gamma\Delta VS_j)][(\alpha+\Sigma\beta_i Z_{ij}+u_j)] \tag{2-43}$$

where VS is given by eq. (2-44) below and BIDj is the willingness-to-pay (WTP) of household j. VS is given by changes in eq. (2-44) due to the program; α is a common intercept term (of rotation, not level of bid); Z is the vector of

household characteristics with parameters B; u_j is the household-specific rotation of the bid curve.

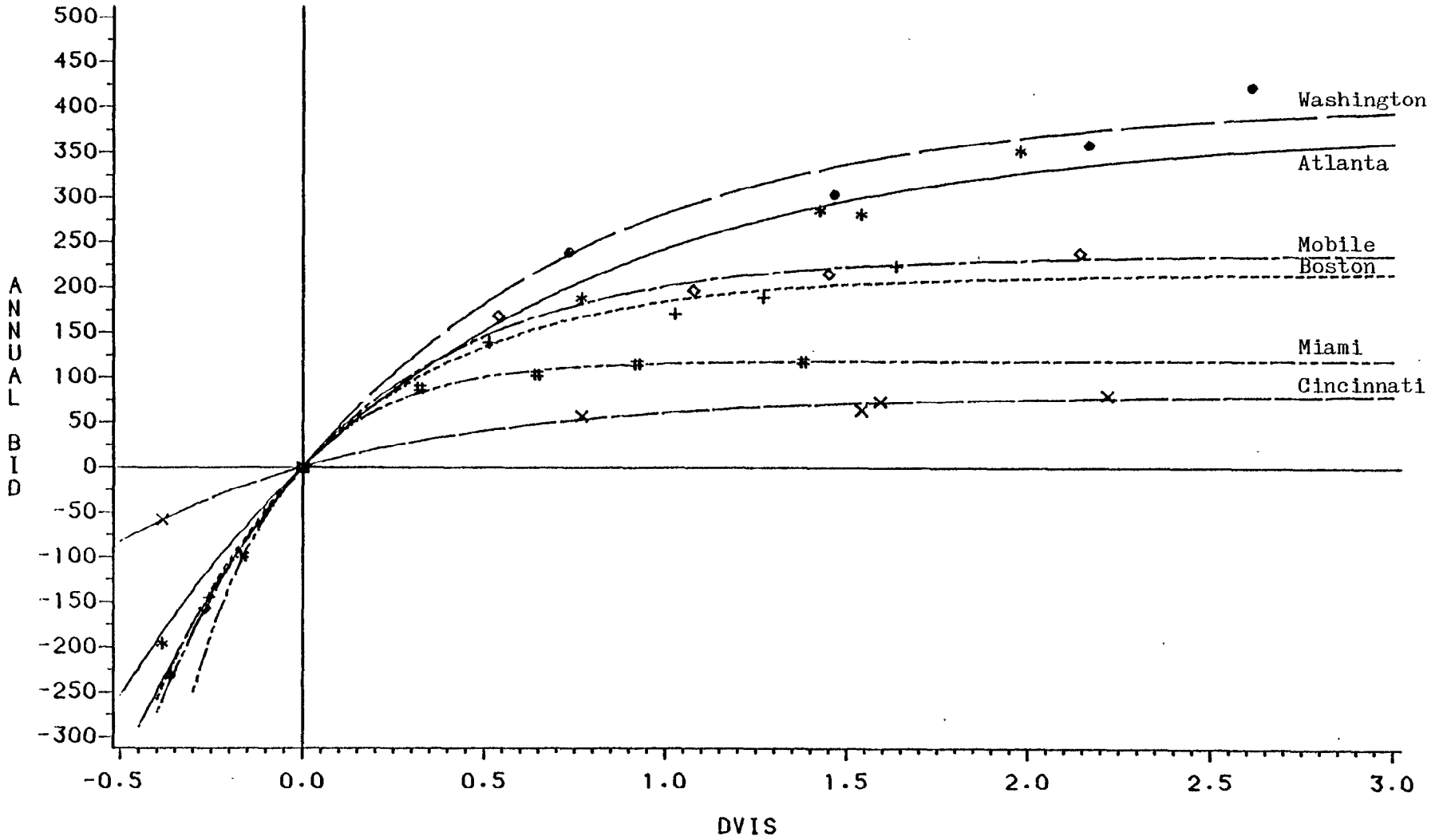
TO demonstate the properties of this function, a bid curve was estimated through each city's mean bids for the five programs. The non-linear regression was run once for each city, estimating only the α and the γ parameters. The hypothetical visibility programs are presented in Ta.2-17. The scenarios are the same in each city, but a given scenario represents different values of VS, depending on the other factors in eq. (2-39). (the parameters of which were estimated from preliminary maximum-likelihood regressions). In Ta.2-18 the initial value of VS, the value of VS for each program, and the mean bids for each program are presented for each city in the sample. The formula used to calculate VS for the empirical analysis is

$$VS_j = \sum_i^i VR_i * SM_i * D_i^{-1.5} \tag{2-44}$$

where the exponent on the distance variable was estimated by a ML method jointly with the vector of household characteristics and the parameter γ, as discussed below. An important result of the derivation of VS is that some cities with very good local visibility conditions appear to have very poor quantities of VS since they have rather poor proximity to the other parts of the country. This is most notable in New England, where VR is the highest in the eastern U.S. but VS is calculated to be among the lowest. Since, in the eastern U.S., centrally located areas tend to have the lowest VR and the peripheral areas have the highest VR the estimated effect of initial VS will tend to be of opposite sign of that of the effect of local VR. If one believes that eq. (2-44) inadequately weights local effects then this will be the direction of change due to increasing this weight.

FIGURE 2-7

Marginal Bid Curves, by City



Note See text for derivation of bid curves

In Figure 3 the mean bids are plotted against VS as calculated in (6) for each of the six cities. For each set of points, a non-linear regression is fit of the form

$$BID = [1-\exp(-\gamma \Delta VS)]^{\alpha} + e \quad (2\text{-}45)$$

The figure shows the plot of the regression lines for each city. It should be emphasized that these city results are illustrative only. The visibility value function finally estimated applied a maximum likelihood approach to eq. (2-43) in which all cities were included in one regression, as will be discussed below.

We now turn our attention to the members of Z, their definitions, and the economic implications of each. Summary statistics of each of these variables can be found in Ta.2-19 for those observations which were used in the final regression i.e. excluding those households which did not report BID or one of the explanatory variables, usually income, and those who identified themselves as protesting the bid framework as strategic bidders. In addition, 21 persons who did not voluntarily identify themselves as one of these were dropped by the investigators for bidding substantially more than their available income, or for inconsistent answers coupled by interviewer reports of confusion.

The first variable we will consider has already been discussed at some length. This is VISENDOW, the initial level of VS as calculated in (2-44) above and reported in Ta.2-18. As discussed above, this variable will capture the net effect of the combination of the pure endowment effect from diminishing marginal utility, the sorting effect, the substitution effect, and the other complications discussed.

The second characteristic to be considered is that of income. A quadratic form is used to estimate the income effect, with a first order variable INCOME, in thousands of dollars, and a second-order term INCOME2, which is equal to INCOME squared. The parameter estimates on these variables (along with INCAGE discussed below) will be used to calculate a point estimate of

TABLE 2-17

Hypothetical Visibility Programs
as Presented to Survey Respondents

Program	Change in Visual Range	Area of Coverage
1	-5 Miles	Local*
2	10 Miles	Local
3	20 Miles	Local
4	10 Miles	Eastern U.S.
5	10 Miles	All U.S.

* Note: Local is defined as all land.area within 75-mile radius of the city center. East U.S. includes all land area east of Mississippi River. All U.S. includes all states except Alaska and Hawaii, and includes District of Columbia.

the income elasticity of demand for VS. This estimate is of interest because most researchers report or suggest that the income elaticity for environmental goods is greater than unity. This data provides a check on this hypothesis.

The number of persons in the household, HSLDSIZ, is important for two reasons having opposite expected signs, making the net effect ambiguous. The first effect is the public good effect within the household itself of the increments in VS. The respondent is asked to accept or reject a program at a given cost to the entire household. Since the good is non-rival, the respondent will sum as accurately as he can the marginal benefit functions of each household member to arrive at the household benefit function.

The other effect, however, works in the opposite direction. The actual disposable income available to the household for the programs is probably calculated by subtracting certain fixed or very inelastic costs from total

TABLE 2-13

Initial Levels of VS and Proposed Changes, by City with City Mean Rids

	Atlanta	Boston	Cincinnati	Miami	Mobile	Washington
1980 Endowment	4.34	4.20	4.51	3.51	4.59	4.66
ΔVS_1^*	-0.02	-0.11	-0.11	-0.01	-0.03	-0.04
ΔVS_2	-0.02	0.05	0.11	0.01	0.02	0.15
ΔVS_3	0.21	0.24	0.34	0.11	0.15	0.35
ΔVS_4	0.26	0.41	0.56	0.14	0.20	0.57
ΔVS_5	0.21	0.17	0.22	0.16	0.21	0.22
BID_1	-195.92	-144.59	-57.48	-98.69	-156.40	-231.70
BID_2	188.39	138.94	56.94	88.47	168.00	238.36
BID_3	286.21	170.56	63.64	104.04	196.68	302.97
BID_4	281.42	188.79	73.53	115.53	214.52	358.14
BID_5	352.81	224.22	79.72	113.34	238.48	421.93

*Change from 1990 Base Case value.

income. These costs, such as food, clothing, etc. are likely to be correlated with household size, so that for a given money income the actual disposable income is reduced as household size increases. Thus the net effect is ambiguous.

Education, HOHED affects BID in two ways, although in this case the two act in the same positive direction. The variable is defined as the number of years of schooling of the head of household. The direct way that education affects BID is through the household production functions for various activities. In the human capital model, education enters the production function as an input. As long as education has a positive marginal product in production of these activities it will positively influence BID.

The other way that education affects BID is through its effect on household permanent income. So far we have looked at current income only. The now classic treatment by Milton Friedman of consumption as a function of transitory and permanent income gives us some guide to the effect of some of the explanatory variables. For a given level of current income, the more educated person will tend to have a higher permanent income, given quantities of other human and nonhuman capital. Thus we would expect BID to be positively affected by HOHED.

Age is a variable that combines permanent income and human capital effects. For many outdoor activities, youthfulness can be considered as an input in production, or at least as a cost-reducing factor. Thus, the direct effect of age would be to reduce the value of increments in visibility.

The permanent income effect also works in this direction. For a given money income, a middle-aged person will tend to have a lower permanent income than a young person, given the usual age-wage profile. Again, if the person is consuming out of permanent income then, in this example, the young person will have a higher WTP.

It is likely that the effects of income and age are not independent. In particular, the marginal propensity to consume VS out of money income may vary with age, aside from the independent effect of age on BID. To capture this effect an additional variable, INCAGE, is introduced which is equal to the product of INCOME and HOHAGE. This variable is included in the calculation of the income elasticity of demand along with the independent income terms.

Two additional variables enter the vector Z which arise partially out of permanent income considerations. These are race and sex. It has been shown that race and sex enter significantly into the earnings function of individuals. Nonwhites tend to earn less, even after controlling for other human capital variables; and the same is true for women. A special problem exists for female-headed households when children are present, especially among poorer households.

In the case of nonwhites, there is often a geographical separation from whites, and often the division is along central city/outlying area grounds. It is not clear what the net effects will be of these variables, but we can guess that the effects will be negative, based on the permanent income analysis. The variable FEM is a dummy for female-headed households (it should be noted that this includes households where both husband and wife are present and the wife responded and listed herself as “head of household”). The variable NONWHITE, also a dummy variable, represents any of the following groups: Blacks, Latinos, Asians, and Native Americans.

We have said that the household’s stock of human and physical capital influences BID by increasing the marginal product of VIS, but that VS may be high already because of the capital that BID is lower in households with large stock of these inputs. One item on the questionnaire asked the respondent to indicate whether or not the household owned or had access to such

things as a private plane, binoculars, telescope, and others. To get a large enough sample to allow estimation of the effect of the physical capital ownership, these responses were pooled so that ownership of any of these specialized capital goods caused the dummy variable EQUIP to be set equal to one Otherwise this variable equals zero.

The view quality from the residence is treated as a special case of physical capital ownership. EXVIEW is a dummy variable which equals one if the respondent believes their view to be excellent or especially attractive, zero otherwise. Aside from the ambiguity resulting from the effect discussed in the preceeding paragraph, view quality is sugject to an additional caveat. A respondent who reports an excellent view might bid a low amount because VS consumption is already very high, or because they are insensitive to VS to begin with, and thus report a good view where other might not. Both of these possibilities are consistent with low WTP. Like EQUIP, EXVIEW cannot be signed a priori

Just as household size is important for the intra-household public good effect, so too will the number of activities participated in by the household be important to the household's WTP for the visibility programs. The variable ACT is a crude measure of the household's participation in various activities throughout the year. The respondent was handed a checklist of activities and asked to indicate those which the household takes part in during a normal year. The excercise was motivated both by the recognition of this intra-household and intra-individual public good effect across activities, and also for its usefulness in getting the respondent to think carefully about the various ways in which visibility entered into their household activities. Presumably, this aided in the accurate revelation of WTP's for the various programs. The variable ACT is just a count of the number of activites checked by the respondent on the list, each receiving equal weight.

One aspect of human capital which closely parallels the discussion of physical capital is the quality of eyesight. If we take extremes, a blind person will likely find changes in VS to be worthless, except insofar as they have indirect benefits such as saftey on commercial airplanes or crossing the street. On the other hand, a person with highly acute vision may find the marginal product of VR to be high in producing more VS, but can see so well already that the increase is of little value. The variable POOREYES is a dummy variable indicating an admission of poor eyesight on the part of the respondent.

The next set of variables addresses the ownership of residential property. The wording of the questionnaire emphasized that the BID would reflect the total cost of getting the program enacted. We recognize,however, that some individuals will not quite appreciate the meaning we are attatching to the word “all” and might believe that their property values might change if a local amenity changes the desireability of living in their city, or they might think that controlling pollution makes life in their city less profitable, thereby reducing property values. We could not be more explicit in steering any such persons away from these ideas, since the very suggestion might well have led to even more suspicion on the part of persons to whom the idea hadn’t occurred.

Aside from this potential flaw in the reported WTP’s, the ownership of property may well indicate real differences in economic value of visibility. If an owner-occupied home provides better opportunities for indoor substitutes for outdoor activities than does a rented apartment, then we should see such households bidding less. Also, if one own income-earning property, then the increase in tenant’s WTP may be partially collected by the owner. Thus, for a given change in visibility the property owner would be willing to pay more, reflecting someone else’s increased welfare. We do not, however, have to worry about double-couting of a single gain. To the extent that this indirect gain

is important, the tenant will subtract an amount equal to the extra rent payments in the new equilibrium, so it is a pure transfer and will not affect the aggregate benefits as calculated in Section 4 of this report. The variable OWN signifies ownership of the housing unit occupied by the household, and the variable PROP indicates ownership of other residential property in the eastern U.S.

Finally, some geographic identifier dummy variables enter the analysis. The first of these is a dummy which equals one if the household is located in a rural area, named RURAL. There are several possible effects of a rural location on the bid function. First, a rural household might receive less benefits from an improvement in air quality centered in the middle of the city. Second, the general view quality may be higher in the rural area; having the effects discussed for EXVIEW. Third, cost-of-living differentials may result in a dollar buying more of other goods in rural areas than in the city, thus reducing BID for a given increase in welfare. This latter effect will also be important in the city-specific effects discussed below. The first and third of these effects tend to reduce bids while the second is ambiguous. Our hunch is that the negative effects will prevail.

In addition to the urban/rural dummy variable a set of four city-specific dummy variables will be used to help account for unexplained differences between cities. Only four can be used since one of the six city degrees of freedom has already been used up by the variable VISENDOW and the intercept uses another. The four cities with dummies are Atlanta, Cincinnati, Miami and Washington, with variable names A, C, M, and W respectively. Boston and Mobile remain as the base. Ta.2-19 gives the variable means for observations used in the regressions reported in section 2.4.5.

2.4.5 Empirical Estimation of Visibility Value Function

Eq. 2-43. has been estimated using a modified Gauss-Newton non-linear

TABLE 2-19

Variable Means for Observations Used in Regression

Variable	Mean
BID	108.704
DVIS	0.852
VISENDOW	3.754
INCOME	23.195
INCOME2	837.070
HSLDSIZ	3.177
HOHED	13.066
HOHAGE	45.391
INCAGE	1027.709
FEMHOH	0.395
NONWHITE	0.323
EQUIP	0.539
ACT	11.919
OWN	0.663
PROP	0.136
EXVIEW	0.491
POOREYES	0.226
RURAL	0.114
A	0.173
C	0.179
M	0.089
W	0.166

regression routine. Overall, between one-half and two-thirds of the variation of BID is accounted for by the explanatory variables, a high amount for cross-sectional survey data of this type. A point-estimate of the income elasticity of 0.539 is computed, holding all non-income variables at their means. This does not support the hypothesis that visibility is a luxury good, but rather that it is in the range of a normal good between zero and one. The first-order effect of income on BID is strongly positive as expected, but the negative second-order effect and the negative income-age interaction effect were somewhat larger than expected (although the direction was correctly forecasted). The negative interaction term confims the hypothesis that the marginal propensity to consume visibility does indeed decrease with age.

The above analysis takes account only of current money income, but as discussed above, stocks of human and nonhuman capital alter expected future income, thus having an effect on current consumption through the permanent income model. Turning to the human capital variables, we find an unexpected result. The estimate of the education parameter is negative, so that more educated person tend to bid less, holding the other variables constant. The explanation for this could be that education can have the same negative property discussed for the case of a good view, so that education, being more or less fixed as far as the individual is concerned, has already increased the productivity of leisure time so much that additions of VR have little additional value.

The variable HOHAGE must be considered jointly with the variable INCAGE. For very low income households, age actually increases WTP for VS, but as this declines until about an income of $9,000 per year the net effect becomes negative. This is not difficult to explain. As age increases, leisure time tends to increase,

especially when one or more household members retire from the labor market. This reduction in the opportunity cost of time will shift out the demand curve for visibility and other leisure inputs. However, there will exist a negative correlation between income of these households and the amount of leisure time available. Thus, an older couple still working full time have a lower demand than if they retired, even though measured income is higher.

Nonwhites bid significantly less than whites, and females bid more than makes. We have no good explanation for the latter finding other than the possibility that women are less suspicious and conservative in responding to the (typcially female) interviewers than were men, although there doesn't seem to be any way for us to test this hypothesis.

Poor eyesight and ownership of specialized capital equipment did not have a clear effect, perhaps confirming our notion of the two underlying and opposing effects discussed earlier. As expected, participation in activities has a positive influence on bids, reflecting the non-rivalness of visibility within the household.

One of the dramatic results is the negative influence of view quality on bids. As discussed previously, it could be the result of diminishing marginal utility comgined with a fixed factor (view). Alternatively, the correlation could be spurious, reflecting the fact that people who are very satisfied with their present view are the ones who will not bid much. Thus, we may in part be measuring the same thing in two different ways. Both of these effects are probably important here.

The property ownership variables were of rather large magnitude, with home ownership having a negative impact and the ownership of other residential property having a positive effect. See the previous discussion of these variables for some possible interpretations of these results.

The package used to estimate the parameters in Ta.2-20 does not provide a confidence interval for estimated bids. It seems likely that Gamma and Alpha have

TABLE 2-20

Non-Linear Least Squares Summary Statistics
Dependent Variable BID

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE
REGRESSION	22	130303017.02030957	5911864.41001407
RESIDUAL		140479409.60049038	44996.60781566
UNCORRECTED TOTAL		270782426.62079995	
(CORRECTED TOTAL)	3143	233630610.1008546	

PARAMETER (VARIABLE)	ESTIMATE
GAMMA	0.700
ALPHA	-472.606
VISENDOW	155.757
INCOME	14.797
INCOME2	-0.029
INCAGE	-0.172
HSLDSIZ	5.327
HOHED	-2.011
HOHAGE	1.586
EQUIP	4.417
EXVIEW	-67.139
BADEYES	12.065
ACT	5.175
PROP	97.183
FEMHOH	50.684
OWN	-138.736
RURAL	-41.049
NONWHITE	-78.691
A	139.928
C	-187.137
M	112.550
W	-17.078

a high degree of correlation, and errors in the Gamma estimate are largely offset by corresponding errors in Alpha. Standard errors are almost irrelevant in this case, as they are only assymptotically valid, and the function is degenerate for values of Gamma near 0. Because of this degeneracy, a direct test of the hypothesis Gamma = 0 is not possible; however, an indirect test of the hypothesis was carried by constraining the estimate of Gamma to be less than 0, and re-estimating the function.

The parameter estimates complete the specification of Equation (5)--the visibility value function. For an example of the uses of this function to estimate aggregate policy benefits see Section 4 of this report.